The Dynamic Behavior of Norwegian Municipalities

An Analysis of Local Government Spending 1972-2008

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Abstract

The aim of this thesis is to develop a framework for analyzing municipal spending behavior over a long time dimension. A panel data set for the period 1974 to 2008 containing expenditure data and other characteristics for all the municipalities constitute the basis of the analysis. We suggest an econometric model specification which is flexible enough to incorporate the major institutional and social changes of the period. We also propose and estimate three models over the full period. One static model, one partial adjustment model without and one partial adjustment model with autocorrelated errors. A discrepancy between the static and the dynamic parameter estimates is found and investigated, but the source has not been uncovered. Analysis of the dynamic models revealed that net operational deficits in preceding years lead to a strengthening of the net operational surplus, which is in line with budget rules imposed on the municipalities. By allowing for heterogeneous adjustment speed in the dynamic models we find that large municipalities adapt more sluggish than small ones to shifting demand. This means that small municipalities implement desired allocation changes faster.

Preface

This thesis marks the end of my five year program at the department of economics, qualifying to the degree Master of Economic Theory and Econometrics.

First of all, I would like to express my gratitude to my supervisor Audun Langørgen for the challenging topic. His patient guidance and insightful comments has been of great value to me. Also, I want to thank Lasse Eika and Simen Pedersen for their contributions to the data sets on which I base my analysis. Terje Skjerpen and Rolf Aaberge have given me valuable comments for which I am grateful.

Last, I want to thank all the employees and students at the microeconomics unit at the Statistics Norway research department where this thesis was written as part of a paid engagement.

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1 Introduction

Municipalities have a responsibility to provide its residents with certain services. Yet the services and the service standards provided have changed a lot over time. Throughout the 1960s many small municipalities and those on the fringe of large cities were forced to merge. This followed in the wake of the Schei-committee whose assignment had been to suggest a new municipal structure that was better prepared to handle an increased part of the national welfare production. Since then an increasing number of responsibilities have been assigned to the municipalities by the central government, resulting in a much more standardized set of services. Combined with more use of earmarked grants and strict limitations to the income tax level the autonomy of municipalities has been severely reduced. This means that much of the income available to local governments is already bound to cover the *minimum required expenditures* required by law. The remainder is discretionary income which can be distributed among the municipal services as the local council sees fit.

A model of municipal sector specific expenditure, referred to as KOMMODE, has been developed in Statistics Norway since 1995. This is a microeconometric model that is based on the utility maximizing behavior of local government, and has been extensively documented in Aaberge and Langørgen (2003), Aaberge and Langørgen (2006), Langørgen, Galloway, Mogstad and Aaberge (2005) and Aaberge, Bhuller, Langørgen and Mogstad (2010) and Langørgen, Pedersen and Aaberge (2010).

Work done at Statistics Norway has extended the data material of the model. As of spring 2012 the municipality data for the years 1972 to 2008 have been collected and prepared for analysis.[1]

The aim of this thesis is twofold. First, to create a panel data set for the period 1972 to 2008 from the available municipality data and suggest an econometric model specification which is flexible enough to be estimated over the entire time segment. To do this the institutional and political framework in which the municipalities operate need to be analyzed to get information on structural changes to the model parameters. Second, to propose a dynamic model setup based on a partial adjustment model with

[1] Prior to this, data has been available for 1993 and 2001-2008

heterogeneous adjustment speed. And to identify and correct issues related to such a dynamic setup.[2]

The rest of the chapters are organized as follows. Chapter 2 contains brief reviews of papers related to the thesis. In Chapter 3 certain theoretical aspects of dynamic panel data modeling are explained. Chapter 4 contains the description and derivation of the base model for municipal spending. In chapter 5 some key changes to the institutional framework in which the municipalities and local government operate are presented and possible consequences for model specification are highlighted. Chapter 6 contains a presentation and a description of four different econometric models which is to be used in the analysis. In chapter 7 the models are compared and the parameter estimates are discussed. Chapter 8 contains a reflection around what has been found, what has not been found and suggested paths for further inquiry.

[2] All analysis was done using SAS software package. Program code is available on request.

2 Literature Review

Several models have been developed to explain different aspects of local government behavior. We will go through some important papers related to the KOMMODE model. Also we will mention some of the research applying partial adjustment models to analyze the dynamics of municipal expenditure.

In their 2003 paper "Fiscal spending behavior of local governments: Identification of price effects when prices are not observed", Aaberge and Langørgen analyze the local public spending behavior in municipalities. Local government utility maximizing behavior is used to derive the extended linear expenditure system (ELES) for eight service sectors. The expenditure on each of these sectors are composed of two parts; the minimum required expenditure level determined by local attributes affecting the cost function and marginal budget shares, which is the share of the disposable income distributed to the sector according to local taste factors such as education level, political composition of the local government council and the degree of urbanization. These eight equations are estimated simultaneously using data from 1993. Identification in the absence of prices on public services is obtained by exploiting the heterogeneity of the municipality specific attributes assumed to influence production costs and local taste variables.

A 12-sector version of the model used by Aaberge and Langørgen (2003) is used in Langørgen, Pedersen and Aaberge (2010) to analyze the stability of the municipality behavior over the period 2001-2008. They find that most of the parameters explaining the minimum required expenditure of the sectors are significant and stable over time. Changes in parameters is attributed to either political or preference changes, dynamic effects that are not modeled or more general misspecification problems and plain statistical uncertainty.

"A study of Norwegian local government behavior in a dynamic context" by Kerimova (2010) analyzes multiple dynamic models on the basis of a panel data set over the years 2001-2008. Several models for handling time and municipality heterogeneity or both is proposed and estimated. This serves as a comparison of different approaches to dynamic modeling, where the advantages and shortcomings of each are discussed. A partial adjustment model, explaining the sluggishness of municipality adjustment to changes in equilibrium, is also modeled. This model is proposed by Kerimova as a useful starting point for further research.

An earlier study of partial adjustment models on municipality spending has been performed by Borge and Rattsø in the 1993 paper “Dynamic responses to changing demand: a model of the reallocation process in small and large municipalities in Norway”. They use a representative voter model where the utility of a single representative household is assumed maximized over an exogenous budget constraint to find the expenditure equations. The role of the relative service sector prices are assumed to be negligible, and the expenditure functions are set up as reduced form functions of private consumption, per capita budget and several municipality specific characteristics. More than 442 municipalities over the period 1984-1987 were used to estimate the model. The sluggishness of adjustment was found to be higher than in other countries. An explanation of this phenomenon is the high degree of central financing implying limited local accountability. Estimations of the adjustment speed were also found to be greater in small municipalities than in larger ones. They suggest that organizational complexity and poor voter control can explain this.

In “Local government service production: The politics of allocative sluggishness” from 1995 Borge, Rattsø and Sørensen use a similar model to find the impact on adjustment from pressure groups. By surveying local politicians they find a measure on pressure from interest groups. They find that interest groups related to primary education increase allocative sluggishness, while those supporting child care and elderly care encourage faster reallocation.

3 Theoretical Framework

Panel data methods have many advantages over cross-sectional or time-series data. Due to the extra dimension it allows more accurate inference on model parameters, attributed both to more degrees of freedom and higher sample variance (Hsiao, 2007). In this chapter we will investigate a few topics regarding to two of the other advantages panel data analysis provides.

Panel data theory has methods designed to handle unobserved heterogeneity in observed units and over time. In any cross section numerous unmeasured variables explain the units we are analyzing. Failure to include these when estimating results in omitted variable bias. In the same way we get a bias when omitting time series variables that influence units uniformly.

Also, panel data methods allow for better analysis of dynamic relationships. While time-series analysis also can examine dynamic effects, panel data can describe more complex dynamic relationships with a shorter time dimension due to the number of units (Kennedy, 2008).

In the following chapter we investigate issues which might arise under the presence of heterogeneity and dynamic model specification. Different methods designed to deal with such issues will be discussed, along with the costs and benefits associated with them. We will also discuss what to expect if such problems are left untreated.

3.1 Unobserved heterogeneity

Unobserved heterogeneity in panel data can take several forms. The basic assumption of unobserved heterogeneity according to Hsiao (2003) is when a model conditional on the observed explanatory variables still has an omitted variables effect, then this effect is driven by three main types of variables; period individual-invariant, individual time-invariant and individual time-varying. Period individual-invariant variables are the same for all individuals in a certain time period, but may differ across time periods. Individual time-invariant variables can be different for each individual in the cross-section, but does not vary over time. Individual time-varying variables vary both across individuals and over time units.

Period individual-invariant heterogeneity can be handled in several ways. The first and obvious method is by adding time dummies for all periods to all observations in the model. These can interact either additively or multiplicatively with the model. These dummies can pick up time effects such as inflation, real growth, changes in preferences or politics depending on the model specification.

Another approach to deal with time heterogeneity is to use price or income indices. If a reasonable index is available it can be used to transform the data before estimating, thus effectively removing the time trend. Using price indices to remove time trends caused by inflation from data is a common use of this approach.

Time dummies generally unveil more new information than the use of an index. But they are also much more computationally costly and prone to cause identification problems.

Unobserved individual time-invariant heterogeneity can be thought of as an individual specific intercept, c_k. Several strategies are available for dealing with this sort of unit heterogeneity in panel data. A regression function with unobserved heterogeneity can be written:

$$y_{kt} = \mathbf{x}_{kt}'\boldsymbol{\beta} + c_k + \varepsilon_{kt}, \tag{3.1}$$

$$k = 1, \ldots, K, \quad t = 1, \ldots, T$$

where $\mathbf{x}_{kt}$ indicates the explanatory variables of unit k at time t and $\boldsymbol{\beta}$ is the corresponding parameters.

With linear pooled panel data models we can perform transformations like first-differencing (3.2) or subtracting the data group means (3.3) to remove such effects. This will remove the unobserved heterogeneity, and allow parameters to be estimated consistently.

$$y_{kt} - y_{kt-1} = \left(\mathbf{x}_{kt} - \mathbf{x}_{kt-1}\right)' \boldsymbol{\beta} + \left(\varepsilon_{kt} - \varepsilon_{kt}\right), \quad k = 1,...,K\ ,\ \ t = 2,...,T \tag{3.2}$$

$$y_{kt} - \bar{y}_k = \left(\mathbf{x}_{kt} - \bar{\mathbf{x}}_k\right)' \boldsymbol{\beta} + \varepsilon_{kt}\ , \quad k = 1,...,K\ ,\ \ t = 1,...,T \tag{3.3}$$

Unfortunately, such transformations do not generally work with models that are nonlinear in parameters.

$$y_{kt} = h\left(\mathbf{x}_{kt}, \boldsymbol{\beta}, c_k\right) + \varepsilon_{kt} \tag{3.4}$$

where h is a nonlinear function.

Greene (2011) shows this approach is pointless. Except for some special functional forms such as an exponential model, the individual heterogeneity or fixed effects cannot be differenced away like in (3.2) and (3.3). Instead we get

$$y_{kt} - \bar{y}_k = h\left(\mathbf{x}_{kt}, \boldsymbol{\beta}, c_k\right) - \frac{1}{T}\sum_{s=1}^{T} h\left(\mathbf{x}_{ks}, \boldsymbol{\beta}, c_k\right) + \varepsilon_{kt}\ , \tag{3.5}$$

which certainly does not simplify matters. A related problem that arises when dealing with unobservable heterogeneity in nonlinear models such as (3.4) is that it is not always clear how it should enter the regression model.

Fixed effects

One way to handle time invariant, individual heterogeneity in a nonlinear model such as described in (3.4) is to use a fixed effects model (FE). The fixed effects model can be used in nonlinear models by adding unit specific dummy variables. In such a model all parameters need to be estimated simultaneously. While estimating such a system can be difficult in its own right, this method also creates problems through a phenomenon called the incidental parameter problem. Neyman and Scott (1948) found that under conditions such that the numbers of parameters were increasing with sample size; the estimators of the constant terms are not consistent. When T is fixed (and small) the slope estimators then become inconsistent and biased to the degree of *O(1/T).*[3] In linear panel data models the use of least squares dummy variables (LSDV) to consistently estimate the slope parameters circumvents this problem. Such an easy fix does not exist for nonlinear panel data models, and larger time dimensions are needed to reduce the incidental parameter bias. One serious limitation with the FE-model is that we lose the contribution from variables that are constant or highly correlated over time. Such variables can still be included when they interact with time varying variables like time dummies, but we can only measure the change in their contribution, not the total contribution.

Random effects

Another approach which also works with nonlinearity is the random effects model (RE). As explained in Wooldridge (2009), this model requires the somewhat strong assumption that the unobserved individual heterogeneity is uncorrelated with all included explanatory variables for all units and all time periods.

$$Cov\left(\mathbf{x}_{kt}, c_k\right) = \mathbf{0}, \tag{3.6}$$

$$k = 1, ..., K, \quad t = 1, ..., T$$

The unobserved effect is then assumed to be a component of the error term. This implies that the error component is serially correlated over time. The serial correlation problem can be solved by using generalized least squares in linear models but do not have any solution methods for nonlinear models (Greene, 2011). One advantage over the FE-model is that the RE models allows variables to be constant over time. However, for the RE model to have good properties K should be fairly large and T should be relatively small.

Pooled regression

Still another approach is to run regressions on the panel data without correcting for individual time-invariant unobserved heterogeneity. Pesaran and Smith (1995) has

[3] The $O(\bullet)$ function is used to describe the limiting behavior of a function. Used in Greene 2011

shown that heterogeneity in the cross-sectional units can produce severely biased results, even when both panel dimensions are large. This may still be preferable to the aforementioned methods.

These approaches have different benefits and costs which all have to be considered in the light of the application. Kerimova (2011) used panel data on the period 2001-2008 to estimate a 12-sector version of KOMMODE. She compared the results of a benchmark model with those from alternative models which corrected for time effects and/or individual fixed effects. Her analysis concluded that the estimates were particularly sensitive to time heterogeneity. Significant municipality fixed effects was also found but were far less prominent.

Since there are reasons to believe that the KOMMODE model does explain the individual heterogeneity well and it uses many variables that vary little over time, the pooled regression seems like a useful approach.

3.2 Dynamic model specification

An interpretation of the predicted expenditure of an expenditure system is that it represents the long-term equilibrium expenditure. In a partial adjustment model the agents are assumed to spend time adapting to a new state when the external conditions change. In the same way that there are obvious welfare costs that incur when being in disequilibrium, there are also costs associated with shifting resources between different states. So the question becomes how fast the resources should be shifted towards the new equilibrium.

This problem can be analyzed by setting up a quadratic cost function (Biørn, 2008).

$$C_{kt} = A(y_{kt} - y_{kt}^{*})^2 + B(y_{kt} - y_{kt-1})^2 \tag{3.7}$$

A rational agent would react to a new equilibrium y_{kt}^{*} by minimizing (3.7), thus adapting at an optimal speed of adjustment.

One way of estimating this adjustment speed is by setting up a dynamic model:

$$y_{kt} = \lambda y_{kt}^{*} + (1-\lambda) y_{kt-1} + e_{kt}, \qquad 0 \le \lambda \le 1 \tag{3.8}$$

where

$$y_{kt}^{*} = \mu x_{kt} + \varepsilon_{kt} \tag{3.9}$$

This is called a partial adjustment model. More generally these types of models are called autoregressive distributed lag ($ADL(p,q)$) models with p lags on the endogenous variable and q lags on the exogenous variables (Patterson, 2000). The partial adjustment model is then a $ADL(1,0)$ model.

Combining (3.8) and (3.9) gives

$$y_{kt} = \lambda \mu x_{kt} + (1-\lambda) y_{k,t-1} + v_{kt} \tag{3.10}$$

where

$$v_{kt} = e_{kt} + \lambda \varepsilon_{kt} \tag{3.11}$$

By specifying the model in this way we find the long-run values of the μ directly. Setting $y_{kt} = y_{k,t-1}$ collapses (3.10) into $y_{kt} = \mu x_{kt} + v_{kt}$.

This basic model creates the framework used for analysis of dynamic relationships in later chapters.

Two main types of bias are typically associated with a dynamic model specification (Hsiao, 2003). One comes from ignoring correlation between time persistent errors and lagged dependent variables. This results in a bias which does not depend on the time dimension of the panel. The other type of bias arises when the initial observation is modeled incorrectly. This is also known as the initial condition problem and causes a bias which diminishes when the time dimension increases. If the time dimension is short, the bias can be eliminated by utilizing information of the dynamic structure of the error term.

3.2.1 Autocorrelated errors

In dynamic models using lagged dependent variables the presence of autocorrelated errors can severely influence the parameter estimates. A partial adjustment model as discussed above uses the characteristic that the lagged endogenous variable is not contemporaneously correlated with the error term to consistently estimate the parameters. Kennedy (2008) advises to routinely test for autocorrelated errors whenever lagged dependent variables are used. In the following section we will examine the bias on the speed of adjustment parameter in partial adjustment models when error terms are autocorrelated.

If we assume (3.10) is correctly specified we could expect the error term to be spherical and estimates of the adjustment speed to be unbiased. However, if we allow there to be some unobserved misspecification of the model, things no longer would be as straight forward.

By rewriting (3.10) as a more general form and dropping the unit specific index to simplify the notation.

$$y_t = \alpha x_t + \gamma y_{t-1} + v_t \tag{3.12}$$

where

$$\alpha = \lambda\mu \text{ and } \gamma = (1-\lambda)$$

We can recover the coefficients of (3.10)

$$\mu = \frac{\alpha}{(1-\gamma)}, \tag{3.13}$$

$$\lambda = (1-\gamma), \tag{3.14}$$

Assuming the error term to follow an autoregressive process of order one (AR(1)) we can restate the disturbance as

$$v_t = \rho v_{t-1} + w_t, \qquad |\rho| < 1 \tag{3.15}$$

Where the w_t is ”white noise”. ’The system (3.12) and (3.15) has the following properties:

$$E(w_t \mid \mathbf{x}) = 0 \tag{3.16}$$

$$E(v_t \mid \mathbf{x}) = 0 \tag{3.17}$$

$$E(v_t v_{t-j} \mid \mathbf{x}) = \begin{cases} \sigma^2 & , j = 0 \\ \rho^j \sigma^2 , & j \neq 0 \end{cases} \tag{3.18}$$

The presence of serial correlation in the disturbances will usually be due to some systematic relationship which the model fails to incorporate. If this relationship cannot be found and modeled correctly it is crucial that the error process is taken into account when estimating the dynamic relationship.

Equations (3.12) and (3.15) can be written

$$y_t = \alpha x_t + \gamma y_{t-1} + \rho v_{t-1} + w_t . \tag{3.19}$$

It is then obvious that if we ignore the autocorrelation in the error term and estimate the adjustment inertia, γ, in (3.12) with ordinary least squares (OLS) we get an endogeneity bias due to the omitted variable. Following the approach used by Griliches (1961) we estimate the inertia parameter in (3.12) with OLS

$$\hat{\gamma}^{ols} = \gamma + \rho \cdot plim\left[b_{v_{t-1} y_{t-1} \cdot x_t} \right]. \tag{3.20}$$

where $b_{yx.z}$ is the regression coefficient of *x* in an auxiliary regression $y = b_{yx.z} x + b_{yz.x} z$.

Using Slutsky’s theorem and convergence in probability together with the property of zero correlation between the exogenous variable and the error term $E\left(v_{t-1} x_t\right) = 0$ we find:

$$plim\left(b_{v_{t-1}y_{t-1}.x_t}\right) = plim\left[\frac{b_{v_{t-1}y_{t-1}} - b_{v_{t-1}x_t}b_{x_t y_{t-1}}}{\left(1 - r[y_{t-1},x_t]^2\right)}\right] = plim\left[\frac{b_{v_{t-1}y_{t-1}}}{\left(1 - r[y_{t-1},x_t]^2\right)}\right]$$

$$\overset{\text{Slutsky}}{=}\left[\frac{p\lim M[v_{t-1}y_{t-1}]}{p\lim M[y_{t-1},y_{t-1}]}\right]\frac{1}{\left(1-r[y_{t-1},x_t]^2\right)} \quad \xrightarrow{p} \quad \left[\frac{E\left(v_{t-1}y_{t-1}\right)}{E\left(y_{t-1}^2\right)}\right]\frac{1}{\left(1-r[y_{t-1},x_t]^2\right)} \tag{3.21}$$

where $M[\ ]$ is the empirical covariance, $r[\ ]^2$ is the correlation and $b_{v_{t-1}y_{t-1}} = \frac{M[v_{t-1},y_{t-1}]}{M[y_{t-1},y_{t-1}]}$.

Since (3.12) can be written like sums of diminishingly influencing past regressors and error terms

$$y_t = \alpha\sum_{s=0}^{\infty}\gamma^s x_{t-s} + \sum_{s=0}^{\infty}\gamma^s v_{t-s} \tag{3.22}$$

and we know that $E(v_t x_t) = 0$ and $E(v_t v_{t-s}) = \rho^s\sigma^2$ we get

$$E(v_t y_t) = \sum_{s=0}^{\infty}\gamma^s E(v_t v_{t-s}) = \sigma^2\sum_{s=0}^{\infty}\gamma^s\rho^s = \frac{\sigma^2}{1-\gamma\rho}. \tag{3.23}$$

Then we can write (3.21) as

$$E\left(b_{v_{t-1}y_{t-1}.x_t}\right) = \frac{1}{(1-\gamma\rho)}\left[\frac{\sigma^2}{\left(1-r[y_{t-1},x_t]^2\right)\sigma_{y_{t-1}}^2}\right]. \tag{3.24}$$

Finally we receive an expression of the asymptotic bias

$$bias\left(\hat{\gamma}^{ols}\right) = plim\left(\hat{\gamma}^{ols} - \gamma\right) = \frac{\rho}{(1-\gamma\rho)}\left[\frac{\sigma^2}{\left(1-r[y_{t-1},x_t]^2\right)\sigma_{y_{t-1}}^2}\right]. \tag{3.25}$$

The OLS estimate of the inertia parameter will be biased when the error term follows a first order autoregressive process. When the persistence parameter (ρ) of the AR(1) process is positive then the inertia parameter is over estimated. It is worth noticing that the bias disappears when $\rho = 0$, meaning we are back to the well behaved case of the classical linear regression model and OLS is BLUE[4]

$$\left.\frac{\delta\left[bias\left(\hat{\gamma}^{ols}\right)\right]}{\delta\rho}\right|_{\rho>0} > 0 \tag{3.26}$$

$$\left.\frac{\delta\left[bias\left(\hat{\gamma}^{ols}\right)\right]}{\delta\lambda}\right|_{\rho>0} < 0 \tag{3.27}$$

This also means that the speed of adjustment parameter $\lambda = (1-\gamma)$ will be under estimated. The under estimation will be aggravated by a high persistence parameter in the AR(1) process. This seems logical given that OLS is unbiased when the persistence is zero. A high adjustment speed will reduce the amount of under estimation.

When estimating municipality expenditure, we already have established that there are some fixed effects present which we do not pay attention to. This will result in autocorrelation in a distributed lag model since the heterogeneity in time t will be correlated with the unit heterogeneity in time $t-1$ through the lagged dependent variable. Thus, a dynamic analysis of municipality spending behavior should investigate the presence of such autocprocesses in the error terms.

3.2.2 Initial condition problem

A common problem in models with lagged dependent variables is that the parameter estimates can be very sensitive to the modeling of the initial values.

Given a simple dynamic model following an AR(1) process:

$$y_t = \alpha x_t + \gamma y_{t-1} + v_t \tag{3.28}$$

$$E\left(v_t \mid y_0, y_1, ..., y_{t-1}\right) = 0 \tag{3.29}$$

$$(t = t_0, ..., T), \quad |\gamma| < 1$$

[4] Best Linear Unbiased Estimator

y_t can then be rewritten as a process of the form:

$$y_t = \alpha \sum_{s=0}^{t-t_0-1} \lambda^s x_{t-s} + \lambda^{t-t_0} y_{t_0} + \sum_{s=1}^{t-t_0-1} \lambda^{s-1} v_t \tag{3.30}$$

$$E\left(y_t \mid \mathbf{X}\right) = \alpha \sum_{s=0}^{t-t_0-1} \lambda^s x_{t-s} + \lambda^{t-t_0} E\left(y_{t_0} \mid \mathbf{X}\right) \tag{3.31}$$

Equation (3.31) shows that the initial condition of the lagged dependent variable will influence the regression. The adjustment speed estimated on short panels under the assumption that $y_0 \mid \mathbf{X}$ follows such a process will be inconsistent if this assumption turns out to be is false. When the time dimension is larger it does not matter much if the regression is estimated conditional on the initial value or not. The question to ask according to Arrelano (2003) is if the initial conditions at the start of the sample are representative with the steady state behavior of the model or not. An example suggested by Barro and Sala-i-Martin (1995) is a time series that started after historical events such as wars. If one estimates growth rates, the GDP of European countries after World War 2 cannot be assumed to be in a steady state.

In our analysis of municipality spending behavior using the full panel data set, we should not be concerned with initial condition bias. For shorter panel data sets this can be an issue, but we should have a reason to assume that the municipality spending is outside a steady state level.

4 The Baseline Model

4.1 Model description

The model of municipal spending behavior, KOMMODE, uses municipality specific cross-section characteristics to explain variations in expenditures. Income and spending data from the local government accounts in Norway is used to create 12 separate service sector definitions, which are supposed to be comparable over time.

1. Administration
2. Primary schools
3. Other education
4. Child care
5. Health care
6. Social assistance
7. Child protection
8. Long-term care
9. Culture
10. Municipal roads
11. Water supply and sanitation
12. Other infrastructure

These twelve expenditure categories together with the net operating surplus are the endogenous variables in the model. The accounting definitions are designed such that these endogenous variables always sum up to equal the revenues in every municipality. This relation is the underlying budget constraint.

The expenditure in each sector is explained by two parts. The first part is the minimum required expenditure and the other part is the desired share of the discretionary income used in this sector. Minimum required expenditure can be viewed as the cost of providing the level of service required by law, or a level commonly agreed to be acceptable. Differences in such subsistence expenditure are explained by municipality specific characteristics such as demographic, geographic or social factors. The discretionary income is defined as the remaining income after the minimum expenditure has been covered in all sectors. This is the part of the income which local governments are free to distribute among their favored sectors. This relative distribution is called the marginal budget share, and is assumed to be influenced by “taste” characteristics such as political composition of the local council, population education level and settlement density.

The econometric model consists of twelve structural equations, each corresponding to one of the service sectors, which are estimated simultaneously. Each equation consists of one endogenous expenditure variable explained by a selection of appropriate exogenous variables on municipality characteristics, while the exogenous “taste” variables explains the use of discretionary income.

All variables have been transformed to per capita values in thousands of kroner where it is meaningful to do so. This means that interpreting the parameter estimates becomes easy and consistent. For instance, if the variable “kilometers of municipality owned road per capita” in the municipal roads sector has a parameter value of 20, then the interpretation is that an extra kilometer of municipal road per capita increases the expenditure need of the sector by 20000 kroner per capita.

4.2 Model specification

Using a notation close to that of Aaberge and Langørgen (2003) and Kerimova (2011) the model can be derived.

The municipality budget constraint is defined as

$$y = u_0 + \sum_{i=1}^{s} p_i q_i \tag{4.1}$$

where y is total income. This income definition can be seen as an aggregate of user fees, exogenous income such as general grants-in-aid from central government, income tax and property tax. Unit price (p_i) and quantity (q_i) determines the municipality expenditure in each of the s sectors, $u_i = p_i q_i$ $(i \neq 0)$. Budget surplus is given by u_0.

The production function of services in a certain sector

$$q_i = f_i\left(\mathbf{x}_i, \mathbf{z}_i\right), \qquad i = 1,...,s \tag{4.2}$$

depends on the factor input vector $\mathbf{x}_i$ as well as a vector of municipality characteristics $\mathbf{z}_i$ that affects production opportunities. By assuming constant returns to scale and cost minimizing, the cost function is given by

$$C_i\left(q_i, \mathbf{w}_i, \mathbf{z}_i\right) = p_i\left(\mathbf{w}_i, \mathbf{z}_i\right) \cdot q_i \tag{4.3}$$

Aaberge and Langørgen (2003) argue that since factor prices $\mathbf{w}_i$ are set in a centralized system of bargaining, most of the variation of unit prices can be attributed to $\mathbf{z}_i$.

Local governments maximize a Stone-Geary utility function

$$W\left(u_0, q_1, ..., q_s\right) = \left(u_0 - \alpha_0\right)^{\beta_0} \prod_{i=1}^{s} \left(q_i - \gamma_i\right)^{\beta_i} \tag{4.4}$$

where

$$\sum_{i=0}^{s} \beta_i = 1 \tag{4.5}$$

and $0 \le \beta_i \le 1 \forall i$, $q_i \le \gamma_i$, $u_0 \le \alpha_0$ is satisfied.

The parameters γ_i and α_0 can be given the interpretation of the minimum acceptable quantities of local government service and minimum allowed net operating surplus respectively.

Maximizing (4.4) subject to the budget constraint (4.1) and (4.5) allows us to find an extended linear expenditure system (ELES)

$$u_i = \alpha_i + \beta_i \left(y - \alpha_0 - \sum_{i=1}^{s} \alpha_i \right), \qquad i = 1,..., s \tag{4.6}$$

The minimum required expenditure in service sector i is $\alpha_i = \gamma_i p_i \ (i \neq 0)$.

$$\alpha = \sum_{i=1}^{s} \alpha_i \tag{4.7}$$

is the minimum required expenditure on total public service. The discretionary income is defined as which $y - \alpha_0 - \sum_{i=1}^{s} \alpha_i$ is distributed between the different sectors by their marginal budget shares β_i.

Equation (4.6) may be decomposed as; the expenditure in sector i is determined by the minimum required expenditure, in addition to the marginal budget share of discretionary income.

To achieve identification of the expenditure system (4.6) an additional restriction is needed in the absence of observable prices. Pollak and Wales (1978) described an approach they called "translating" the system. By allowing parameters to be heterogeneous with identifying functional form, a fully identified version of the expenditure system is derived.

Heterogeneity in cost parameters can be explained by the municipality characteristics that affects the production function (4.2), while the marginal budget shares, or taste parameters, are explained by factors assumed to influence local government priorities.

$$\alpha_i = \alpha_{i0} + \sum_{j=1}^{k} \alpha_{ij} z_j \,, \qquad i = 1,..., s \tag{4.8}$$

$$\beta_i = \beta_{i0} + \sum_{j=1}^{m} \beta_{ij} v_j \,, \qquad i = 1,..., s \tag{4.9}$$

These equations account for minimum required expenditures per capita (4.8) and marginal budget share (4.9) of each sector given observable municipality characteristics $\mathbf{z}$ and local government taste variables $\mathbf{v}$. In service sectors which do not target the entire population[5] the constant terms are excluded. This is a fair assumption since these

5 Primary schools, other education, child care, social services, child protection and long-term care.

sector expenses must be allowed to vary with the target groups, also it helps identifying the system.

For (4.5) to hold we also need to impose two additional restrictions.

$$\sum_{i=0}^{s} \beta_{ij} = 0 \tag{4.10}$$

$$\sum_{i=0}^{s} \beta_{i0} = 1 \tag{4.11}$$

4.3 Basic panel data model

The most basic panel data model of KOMMODE is just a pooled panel model. Each observation of a municipality in time is basically treated as a separate municipality. The municipality index *k* is implicit in this and in later panel models.

$$u_{it} = \alpha_{it} + \beta_{it}\left(y_t - \sum_{i=0}^{12} \alpha_{it} \right) + \varepsilon_{it} \ , \tag{4.12}$$

$$i = 1,...,12 \ , \quad t = 1,...,T \ , \quad k = 1,...,K$$

The error terms of the sectors have zero expected mean and are contemporaneously correlated due to the interactions of the endogenous variables throughout the system.

$$E\left(\varepsilon_{it} \mid \mathbf{X}\right) = 0 \tag{4.13}$$

$$Cov\left(\varepsilon_{it,}\varepsilon_{jt} \mid \mathbf{X}\right) = \begin{cases} \sigma_i^2, & i = j \\ \sigma_{ij}, & i \neq j \end{cases} \tag{4.14}$$

$$i = 1,...,12 \ , \quad t = 1,...,T \ , \quad \mathbf{X} = \text{(all exogenos variable)}$$

If variables change over time due to political changes, social changes or inflation and real growth then estimating this model over long time intervals will obviously lead to biased results due to misspecification. Earlier estimations by Kerimova (2011) and Pedersen (2008) has shown that parameters change a great deal. Preliminary studies using the cross-sectional version of KOMMODE over the period 1972-2000 also support this. For instance, it is obvious that the minimum required expenditures of the different sectors have changed a great deal from 1972 to 2008 in nominal terms.

If variables explaining such change are not included in the model, then omitted variables or comparability problems will produce biased estimates. We will deal with such problems in panel data models in chapter 6. It may be worth noticing that this model collapses to the cross-section model derived above when the time interval only includes one period.

4.4 Price and expenditure indices

Price and income indices are used in able to compare observations that may not be directly comparable. If we were to compare GDP between different countries by looking only at numbers measured in national currencies would make no sense. A currency exchange index needs to be used to perform such a comparison. This is the comparability problem. In the same way an index is needed to compare nominal variables from different points in time. Because of inflation and real growth we need to use different indices depending on what we want to compare.

A price index measuring municipality consumption prices is used to separate out inflation effects from nominal variables. This can be used to remove the part of the time heterogeneity present in the models attributed to price change. Local public consumption is defined as the total cost of goods and services used by the municipalities and counties. This is composed of the cost of the goods and services produced directly by the municipalities excluding whatever fee income that might have been charged, and the cost of goods and services bought from the private sector.[6]

The yearly growth rate of municipal consumption can be written as the relative change in price of municipality consumption.

$$g_t = \frac{P_t - P_{t-1}}{P_{t-1}}, \tag{4.15}$$

[6] Purchase of private goods and services amounted to 7% of municipality consumption in 2007 (TBU, 2008).

or equivalently

$$P_t = \left(1 + g_t\right) P_{t-1} \tag{4.16}$$

Where P_t is the price level in year t, P_t is the price level in year $t-1$ and g_t is the price growth in year t (Langørgen, Pedersen and Aaberge, 2010). Equation (4.16) allows us to find the relative price index between different years. By normalizing the price index of a base year to 1, we get a series of price indices describing the price level relative to the base year. Data on yearly growth of municipality consumption is collected and presented in the Norwegian National Accounts. Since there has been positive growth in municipal prices throughout the period relevant for this thesis, the price index is increasing over time. We can use the following notation to indicate the municipality consumption price adjusted values.

$$\tilde{u}_{it} = \frac{u_{it}}{P_t}, \qquad \tilde{y}_t = \frac{y_t}{P_t}. \tag{4.17}$$

where $\tilde{u}_{it}$ is the expenditure in sector i in year t. Likewise $\tilde{y}_t$ is the income in year t measured in base year prices.

As an alternative way to account for time heterogeneity we construct an income index or a series of sector specific expenditure indices. In long panel datasets the relative expenditures in the different sectors will typically change a lot as priorities change over time. A sector specific index can be used to control for this type of heterogeneity. Such an expenditure index can be constructed by measuring the relative population weighted average sector expenditure of one year relative to that of a base year.

$$S_{it} = \frac{\overline{u}_{it}}{\overline{u}_{i,base}} \tag{4.18}$$

where

$$\overline{u}_{it} = \frac{1}{n_t} \sum_{k=1}^{K} n_{kt} u_{ikt} \tag{4.19}$$

$$i = 1,...,s \quad , \quad t = 1,...,T$$

Population in municipality k in year t is denoted n_{kt} while n_t is the aggregate population in year t. We can express the inflation adjusted sector expenditure index as

$$\tilde{S}_{it} = \frac{\bar{u}_{it} / P_t}{\bar{u}_{i,base} / P_{base}} = \frac{\bar{u}_{it}}{\bar{u}_{i,base}} \frac{1}{P_t} = \frac{S_{it}}{P_t} \,. \qquad (4.20)$$

This means that $S_{i,base} = 1$, and as long as the same base year is used for the price index $\tilde{S}_{i,base} = 1$. Since these expenditure indices pick up how sectors have been prioritized over time as well as real income growth, an expenditure index from a year preceding the base year need not have a value below that of the base year.

We now have different deflators which can be used to control for time heterogeneity in our models. In the following chapters we will use the different types of deflators extensively. Throughout this thesis 2008 will be used as base year.

More information on the different index values can be found in appendix A.

5 Institutional Context

The provision of public services in Norway is divided between the state, the county and the municipalities. Which services fall under the different administrative levels has changed several times in the recent past. We aim to analyze a model describing the sector-specific expenditures of municipalities over the time span of 1972-2008. Keeping track of the responsibilities assigned to the municipalities within each sector then becomes important. This kind of information is especially important when deciding whether to include structural changes in the model.

5.1 Short description of important events

5.1.1 Social reforms

Nursing homes

The responsibility of providing nursing homes was in 1988 transferred from county to municipal governments. There was a consensus that this assignment had become a natural part of the elderly care services, which was the responsibility of the municipalities. It was assumed that placing similar services under the responsibility of a single governing level would provide better overview of the services provided to the group and improve the service as a whole. The municipalities were compensated by getting a higher grant-in-aid from the central government according to their share of “inhabitants 80 years or older”.

Mentally disabled

A social reform was introduced in 1991, deinstitutionalizing the care of mentally disabled persons as well as defining their rights to many different services. With the reform the responsibilities to provide schooling, childcare, housing, activity and health services, which before had been poorly defined, became entirely that of the municipality (St.Meld. nr. 67 (1986-87)). With the dismantling of the county institutions program approximately 5000 users where moved to housing projects in their home municipality. With those that stayed in the municipality in which they had earlier been institutionalized followed a special grant designed to compensate for the extra cost. Only two years after the reform the number of mentally disabled persons with offers to live in a fitting housing arrangement had increased from 4600 to 7000 (Sosialt Utsyn 2000).

School reform

A school reform in 1997 extended the obligations of the municipalities to offer primary education. Most notable was the extension to the length of the primary school education by an extra year. The municipalities were compensated trough the grant-in-aid system. The reform also made it mandatory to offer a before and after school program, for which they received compensation trough a designated grant as well as over the block grant system.

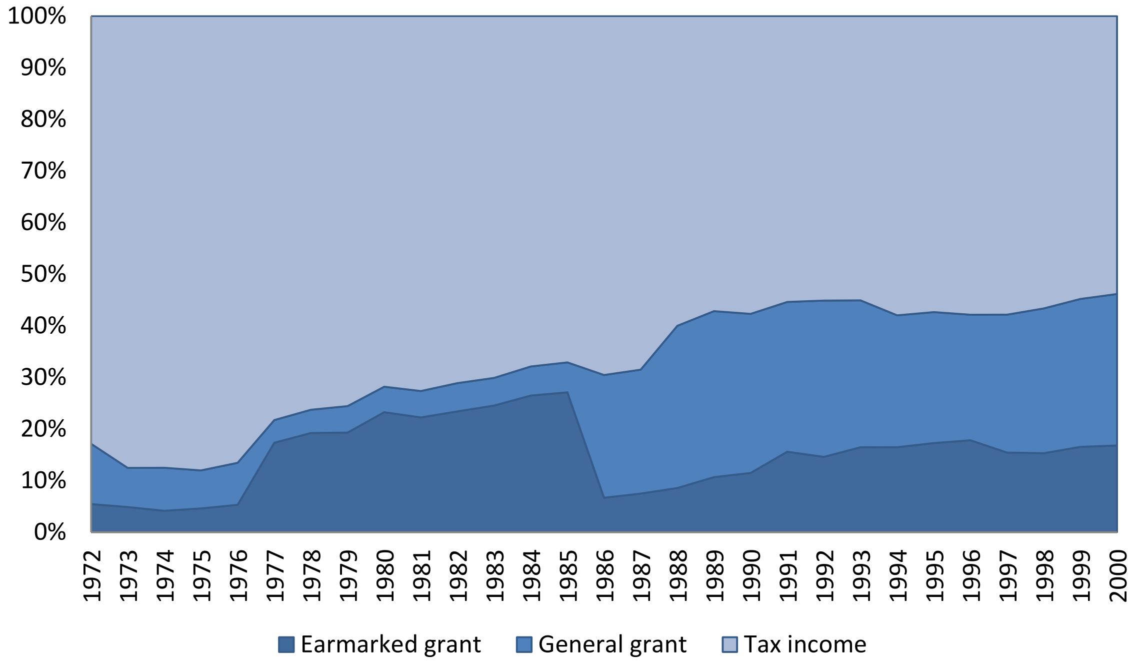
5.1.2 The grant reform of 1986

Other types of reform may also influence local government behavior. Financial reforms change how municipalities get their income and how they can spend it.

From 1970 to 1985 the income of the municipalities only grew from 15.2 percent to 17 percent of GDP (NOU 1997:8). But the composition of the income changed dramatically. Extended use of expenditure reimbursements and earmarked grants had increased the dependence on transfers from the central government. From 1974 to 1985 such transfers as share of total municipal incomes more than doubled. The many different earmark grants and reimbursement schemes made the income system overly complex. This made it difficult for local governments to predict future income and to plan ahead.

In 1986 the financing of the local public sector in Norway was reformed (Ot.prp. nr. 48 (1984-85)). The new finance system set up to equalize tax income and spending needs across municipalities. A block grant system based on objective criteria such as demographic structure was meant to capture differences in spending needs. The reform process started two years earlier when the government created two grants based on objective criteria to simplify the financing of the health service and the social service. In 1986 block grants also replaced much of the financing of the primary school sector and the culture sector. In this process around 50 earmarked grants was replaced by the block grant system.

Figure 5.1. Composition of municipality income, percent



Source: Norwegian municipal accounts

The reform can easily be seen in figure 5.1 as a sharp decrease in earmarked transfers countered by a sharp increase in general grant. It is also apparent that the use of earmarked grants has been steadily increasing since the reform. This is not surprising since earmarked grants are important political tools used to coerce municipalities to adopt the desired changes. In the next segment we highlight some important earmarked grants that have been increasing after 1986.

5.1.3 Earmarked grants

Child care grants

Much of the increase in the use of earmarked grants after the general block grant reform in 1986 as indicated by figure 5.1 can be attributed to the increase in child care grants. This grant was intended to be included in the general block grant system, but practical difficulties concerning the financing of private day care centers repeatedly delayed such integration (Ot.prp. nr 48. 1984-85). Frequently being the target of political attention and aspirations also made it a difficult earmark to remove. The grant was mainly awarded per child, although somewhat differentiated according to age and number of hours of care per week. Between 1985 and 2000 the nominal size of the grant grew from 661 million to 4584 million yearly. This is still over 300 percent growth when adjusting for municipality service price increase.

Host-municipality grants

The social reform in 1991 concerning the care of the mentally disabled was accompanied by a special purpose grant. When the county run institutions for the mentally disabled were closed, many of the former users did not relocate back to their home municipalities. The grant was given to the host-municipalities where the institutions were located to compensate for the cost this incurred. The grant, in nominal terms, increased from 850 million in 1992 to about 2200 million in 1996.[7] Since 1996 the costs are slowly being phased out as the number of former institution users also decrease over time.

Elderly care grants

The elderly care initiative from 1998 led to a massive increase in a few earmarked grants. The operating grant for elderly care services was increased yearly by 810 million, from just 504 million in 1997 to 3495 million in 2001 in nominal terms according to Hole and Gjelsvik (2007). The number of elderly people older than 67 years of age and a measure of mortality was used as criteria for distribution of the grants, conditional on the actual production in the service sector (Riksrevisjonen Dokument Nr. 3:9 (2003-04)).

5.2 Accounting data quality 1972-2008

Statistics Norway receives detailed reports from Norwegian local government accounts each year. By definitions described in Langørgen et al (2005), Langørgen (2012b) and (2012c) the local government accounting items are aggregated up to explain the

[7] Source: TBU:1991 - TBU:2000

municipality expenditure in twelve separate service sectors. This aggregation has been performed for each municipality from 1972 to 2008.

Changes to the accounting practices in 1983, 1991 and in 2001 have made it necessary to "translate" the modern expenditure definitions when using older account data. This translation makes the definitions comparable over time, but when performing analysis on panels which stretches over two or more of these accounting regimes we need to pay special attention to structural change. Special notice should also be paid to the *other infrastructure* sector as it contains expenditure information associated with municipality run/owned commercial activity. The issue is that a lot less of this activity was written to the sector after the accounting change in 1991 than before. Social assistance sector expenditures are also reported to experience some inconsistencies before and after 1991.

5.3 Structural changes

Social and financial reforms can be expected to change the parameters of the model. Such changes need to be modeled explicitly to avoid misspecification of the model and biased estimates. In some cases these changes are unambiguously linked to a certain variable, but it may not always be so clear-cut. Due to the long time dimension it is also necessary to model larger social trends. One approach to find such trends by analyzing preliminary cross-sectional estimates of the model.

The administration sector is influenced by the 2001 change in accounting definitions. Panel data estimation over this year should control for this change.

Primary school sector experienced an increase in expenditure with the 1997 primary school reform. The parameter estimating the cost of share of population in primary school age is expected to change.

Other education sector is subject to several structural changes. Before- and after school programs have been available in Norway in different forms since the 19th century. With the introduction of the law of child care from 1953 a framework standardizing the organization of such programs was established (NOU 1996:13). Before the 1980s the program mostly existed in the big cities, and in small scale in other municipalities up to 1990. The rules governing the program and its funding were revised in 1991, leading to a tremendous growth in the number of participating children. With the 1997 school reform each municipality was required to provide after school programs. Children in primary school age with parents working full time can be expected to have extra need for before- and after school programs. Setting the parameter for this variable equal to zero before 1991 will better explain this sector as this was not a common municipal service prior to this. Special schooling of refugees is also the responsibility of the municipalities. The preliminary studies indicated that the contribution from such groups was not statistically significant prior to 1991.

Child care expenses have been steadily increasing throughout the period. An obvious trend has been that the service has increasingly been targeting the entire population of children in pre-school age. Preliminary cross-sectional studies suggest that special need groups such as children with working parents and children with single provider explained more of the variation in the seventies and early eighties. Social assistance service costs should increase with the share of refugees after the implementation of an integration grant in 1991. The grant is not earmarked but is assumed to exemplify the expenditure need of the refugees in the municipality. Since refugees who trigger the grant and other refugees are assumed to have overlapping needs, both groups should explain expenditure variation in this sector. Another trend in the social assistance sector is the amount of expenditure variation explained by the divorced or separated share of the population. While this group explains quite a lot of the expenditure in the early years, its effect seems to diminish with time.

Long-term care sector expenditures per capita increased significantly in 1988. The cause of which being the reform of elderly care where the responsibility of nursing homes was transferred from the county to the municipalities. The municipalities received extra transfers for the share of population 80 years or older, and it is expected that this group becomes more costly after the reform.

The Culture sector per capita expenditures are mostly stable throughout the period. But the parameters seem to be sensitive to the shifts in accounting regimes. This may be due to changes in how the administrative expenses in the sector are recorded. In 1986 the earmarked culture grants was moved into the block grant system.

The remaining sectors (health care, child protection and the three infrastructure sectors) are not affected by any clear structural brakes. There is however a comparability problem in the expenditure level of the “other infrastructure” sector as mentioned in chapter 5.2. This causes the expenditure levels to be overstated prior to 1991. This needs to be taken into account when estimating the model.

In order to explain the *net operating surplus sector* in a dynamic framework, a fruitful point of departure is to examine the rules of fiscal policy imposed on the local governments by the central government. The law of municipalities from 1954 placed firm restrictions on the budgets proposed by local councils (Hole and Gjelsvik, 2007). The chief administrative officer was required to control the legality of all decisions made by the local councils. Municipalities had to follow a balanced budget regime. Any deficit was to be covered in entirety by the next budget. In rare cases the chief administrative officer could allow the municipalities to cover a deficit over a period of a few years. Any operating surplus was also restricted and could only be spent on capital purposes. They could not be allocated to cover expenditures in later years. In 1993 the laws governing net operating surpluses were liberalized, allowing direct transfers between the budgets of subsequent years. The idea being that greater budgeting flexibility facilitates better long term planning. The next change to the budgeting rules came with the 2001 revision of the law of municipalities. This further liberalized the budgetary rules of the municipalities. Now only the local governments who either planned to run a deficit or were in the process of covering an earlier deficit needed to get their budgets approved by the chief administrative officer. These municipalities were placed in the “Register for State Review and Approval of Financial Obligations”[8] (Hopland, 2012). Municipalities outside this register now had complete freedom to raise loans and shift funds between budget years.

[8] Usually called the ROBEK-list from the abbreviation of the Norwegian expression.

6 Panel Data Models

To perform the analysis we will propose four different econometric models. Each model is a system of twelve equations estimated simultaneously with full information maximum likelihood (FIML). Throughout all the models the data will always be reported in 2008 prices. The municipality subscript k is dropped from all models for the sake of simplicity. And if nothing else is specified the error term of each sector is assumed to have conditional expected value of zero, and are correlated across sectors but not across time periods. The models proposed for analysis are:

(Model 1) Static model with multiplicative time effects

(Model 2) Static model with sector specific expenditure indices

(Model 3) Partial adjustment model with sector specific expenditure indices

(Model 4) Partial adjustment model with sector specific expenditure indices and autocorrelated error terms

6.1 Static model with multiplicative time effects

The first model is a static panel data model with multiplicative time effect. These effects are assumed to scale the minimum required expenditure of each sector. Inflation has been removed from all expenditure and income variables by transforming them with the municipality price index. This leaves real income growth and other unobservable effects affecting sector growth to be explained by the time parameters. Such effects can be regulatory regime changes and changes to government policy.

Model 1

$$\tilde{u}_{it} = \alpha_{it}\tau_{it} + \beta_{it}\left(\tilde{y}_t - \sum_{i=0}^{12}\alpha_{it}\tau_{it}\right) + \varepsilon_{it} \tag{6.1}$$

$$i = 1,\dots,12, \quad t = 1,\dots,T$$

where i is the sector index and t is the time index.

The time effects are modeled by having them interact with time dummies $d_t = 1[t = year]$ for each year and multiplying them to the minimum required expenditure. All the time dummy parameters in the net operating surplus sector are fixed equal to one, $\tau_{t0} = 1$. Both since it is not meaningful to measure the time effect in this sector and to ensure identification. In order to easily interpret the time dummy estimates we normalize the last parameter in each sector to unity, $\tau_{T,i} = 1$. The other time parameters will then capture individual-invariant time heterogeneity such as real income growth and inter-sectorial priorities relative to the base year.

6.2 Static model with sector specific expenditure deflators

Time heterogeneity can be dealt with in other ways than estimating dummy parameters. In this model we use the inflation corrected sector specific expenditure level $\tilde{S}_{it}$ to transform away much of the unobserved sector variation.

Model 2 $$\tilde{u}_{it} = \alpha_{it}\tilde{S}_{it} + \beta_{it}\left(\tilde{y}_t - \sum_{i=0}^{12}\alpha_{it}\tilde{S}_{it}\right) + \varepsilon_{it} \qquad (6.2)$$

$$i = 1,...,12, \quad t = 1,...,T$$

where i is the sector index and t is the time index.

The predicted minimum required expenditures of a certain year can be recovered by scaling the predicted alphas with the expenditure index of that year. Scaling with the price adjusted expenditure index gives us the minimum required expenditures in base year prices (6.3), while scaling with only the expenditure index gives us the minimum required expenditures in nominal prices (6.4).

$$\hat{\alpha}_{it}^{base} = \hat{\alpha}_{it}\tilde{S}_{it} \qquad (6.3)$$

$$\hat{\alpha}_{it}^{nom} = \hat{\alpha}_{it}S_{it} \qquad (6.4)$$

6.3 Partial adjustment model with sector specific expenditure deflators

By using model 2 as a formulation for the equilibrium values in a modified version of the dynamic model (3.10) we can set up a partial adjustment model. λ is the adjustment speed parameter, measuring the rate at which the municipalities shift resources to move from a past expenditure level to the equilibrium level.

$$\tilde{u}_{it} = \lambda \tilde{u}_{it}^{*} + (1-\lambda)\left[\tilde{u}_{i,t-1} + \delta_i(\tilde{y}_t - \tilde{y}_{t-1})\right] + e_{it} \tag{6.5}$$

$$\tilde{u}_{it}^{*} = \alpha_{it}\tilde{S}_{it} + \beta_{it}\left(\tilde{y}_t - \sum_{i=0}^{12}\alpha_{it}\tilde{S}_{it}\right) + \varepsilon_{it} \tag{6.6}$$

where i is the sector index and t is the time index.

One thing that separates this model from (3.10) is that the real income growth is distributed among the service sectors as estimated by the delta parameters. This limits overestimation of the adjustment speed caused by income growth. We require the real income growth to be fully distributed among all twelve service sectors and the net operating surplus sector, which implies (6.7).

$$\sum_{i=0}^{12}\delta_i = 1 \tag{6.7}$$

This requirement also assures that the budget constraint (4.1) holds. Using equations (6.5), (6.7) and the zero expected mean assumption of the error terms we can write:

$$\begin{aligned}&\lambda\sum_{i=0}^{12}\tilde{u}_{it}^{*} + (1-\lambda)\sum_{i=0}^{12}\left[\tilde{u}_{i,t-1} + \delta_i(\tilde{y}_t - \tilde{y}_{t-1})\right] + \sum_{i=0}^{12}e_{it} \\ &= \lambda\tilde{y}_t + (1-\lambda)\tilde{y}_t = \tilde{y}_t\end{aligned} \tag{6.8}$$

The dynamic models use a modified version of the equation explaining net operating surplus. This is a quasi-dynamic equation which allows current net operating surplus to be influenced by past deficits.

$$\alpha_0 = \alpha_{00} + \alpha_{01} \cdot \omega_{t-1} \cdot \frac{u_{0,t-1}}{p_t^m} + \alpha_{02} \cdot \omega_{t-2} \cdot \frac{u_{0,t-2}}{p_t^m} \tag{6.9}$$

where

$$\omega_t = 1\left[u_{o,t} < 0\right] \tag{6.10}$$

This relation is assumed to hold due to the rules explained in chapter 5.3 where successive net operational deficits are prohibited. Deficits in earlier periods should then strengthen the current net operating surplus. When explaining net operating surplus with (6.9) we lose the first two years of observations. A full blown dynamic net operating equation would have required an extension to a model with an intertemporal budget constraint.

Combining (6.5) and (6.6) gives us the final model

$$\tilde{u}_{it} = \lambda\left(\alpha_{it}\tilde{S}_{it} + \beta_{it}\left(\tilde{y}_t - \sum_{i=0}^{12}\alpha_{it}\tilde{S}_{it}\right)\right) + (1-\lambda)\left[\tilde{u}_{i,t-1} + \delta_i(\tilde{y}_t - \tilde{y}_{t-1})\right] + v_{it} \tag{6.11}$$

Model 3

$$i = 1,...,12, \quad t = 2,...,T$$

where i is the sector index and t is the time index.

We want a model where different hypothesis on the dynamic behavior of the local governments can be easily tested. One way to do this is to allow for heterogeneity in the adjustment speed.

$$\lambda = \lambda_0 + \sum_{j=1}^{J}\lambda_j e_j \tag{6.12}$$

With (6.12) we assume that different factors influence the adjustment speed. These factors can be seen as a subset of the cost and taste factors determining the minimal required expenditure level and the marginal budget share of the disposable income.

This means we can estimate how the different variables influence adjustment speed. Especially we want to check the results found by Borge and Rattsø (1993) suggesting slower adjustment speed in larger municipalities.

6.4 Partial adjustment model with sector specific expenditure deflators and autocorrelated error terms

Earlier work by Kerimova (2011) has suggested that there is some unobserved individual heterogeneity present in the model. Such a model will produce autocorrelation in the error terms since the fixed effects in one period will be correlated with the fixed effects in the following period through the lagged dependent variable. As shown in chapter 3.2.1 the estimates of the dynamic parameters in such a model can be seriously biased when the serial correlation is neglected. To deal with such problems a version of the dynamic model with error terms following a stable autoregressive process of order one is proposed. In preliminary studies, other possible autoregressive error specifications have been investigated but have not been found to add much to the analysis.

$$\tilde{u}_{it} = \lambda\left(\alpha_{it}\tilde{S}_{it} + \beta_{it}\left(\tilde{y}_t - \sum_{i=0}^{12}\alpha_{it}\tilde{S}_{it}\right)\right) + (1-\lambda)\left[\tilde{u}_{i,t-1} + \delta_i(\tilde{y}_t - \tilde{y}_{t-1})\right] + v_{it} \qquad (6.13)$$

Model 4

$$v_{it} = \rho v_{i,t-1} + w_{it} \qquad (6.14)$$

$$i = 1,\dots,12\,, \quad t = 2,\dots,T\,,$$

where i is the sector index and t is the time index. We also assume $|\rho| < 1$ and that w_{it} is "white noise". Except for the error term this model is identical to model 3.

7 Estimation Results

Looking at a panel data set with over 400 units and a long time dimension, the sheer number of observation makes it relatively easy to obtain statistically significant estimates. This makes it necessary to also consider the economic significance of our results. Earlier work on the KOMMODE model has produced some sets of variables that explain the minimum required expenditure in the different sectors well. Much time during the writing of this thesis has also been applied to finding such a set that works for the entire range of the panel data set.

Two different specifications for the minimum required expenditures are used depending on the time interval to be estimated. A basic specification is used for shorter intervals, while an extended specification is used to estimate over 1974-2008.

Basic specifications for minimum required expenditures

The basic setup includes only a few structural changes. The reforms regarding the care for the mentally disabled, and the financing of refugees and afterschool programs suggest that variables explaining these expenses should be omitted prior to the reforms. This is done by setting the parameters to zero for the appropriate segment. These parameters are described in table 7.1 below. Misspecification due to parameters changing over time is handled by estimating the model on sub-segments rather than on the full interval of the dataset.

Table 7. 1. Basic minimum required expenditure specifications

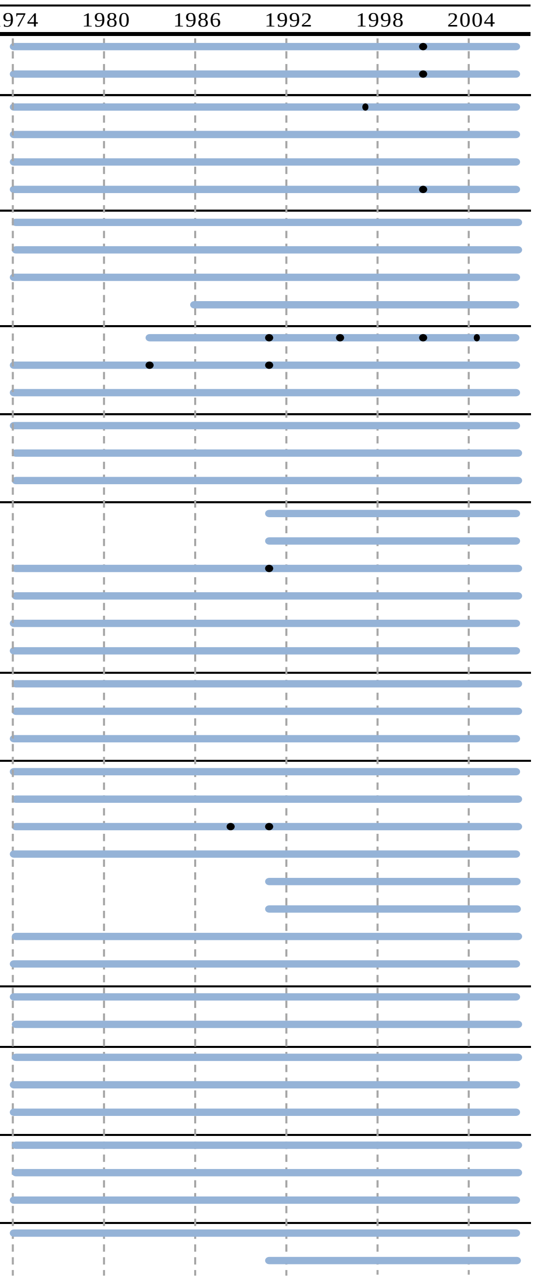
Sector	Variable	Active since:
Other education	Children in primary school age without working parents.	1991
Other education	Refugees with integration grants..	1986
Social assistance	Refugees with integration grants.	1991
Social assistance	Refugees without integration grants.	1991
Long-term care	Mentally disabled adult with grant.	1991
Long-term care	Mentally disabled adult without grant.	1991

Extended specifications for minimum required expenditures

Estimating the models over several segments is a simple way to deal with misspecification problems. In order to estimate over the full panel data set such changes in the parameters still need to be dealt with to get consistent estimates. This can be done by using knowledge about the institutional framework and social changes to explicitly model the structural changes described in 5.3. Descriptive statistics and other examinations of the available data should also be used to create a specification of the model that fits well over the entire dataset. The extended model setup will include many structural changes to reduce misspecification problems. Table 7.2 illustrates the structural changes we have found to be fitting.

Table 7.2. Structural changes in the extended specification

Administration	Constant term
	Inverse population size
Primary school	Population in elementary school age
	Population 13-15 years of age
	Distance to centre of municipal sub-district
	Inverse population size
Other education	Constant term
	Population in primary school age
	Children in child care age w/ emloyed providers
	Refugees living 5 years or less in Norway
Child Care	Population in child care age
	Children in child care age w/ employed providers
	Children in child care age w/ single provider
Health care	Constant term
	Distance to centre of municipal sub-district
	Inverse population size
Social assistance	Refugees living 5 years or less in Norway
	Refugees living more than 5 years in Norway
	Divorced/separated 16-59 years
	Unemployed 16-59 years
	Number of poor
	Disablement pensioners 18-49 years of age
Child protection	Population less than 16 years of age
	Children less than 16 years w/ single provider
	Poor children less than 16 years of age
Long-term care	Population less than 67 years of age
	Population 67-79 years of age
	Population 80-89 years of age
	Population more than 89 years of age
	Mentally disabled over 16 years w/o grant
	Mentally disabled 16 years and above w/ grant
	Distance to centre of municipal sub-district
	Inverse population size
Culture	Constant term
	Inverse population size
Municipal roads	Constant term
	Amount of snowfall
	Kilometers of municipal road
Water/sanitation	Constant term
	Capacity of advanced purification
	Inverse population size
Other infrastr.	Constant term
	Inverse population size



The bands indicate which years the variable is included in the model. The black dots indicate structural breaks.

These extended specifications are used whenever the models are estimated over the full range of the panel data (1974-2008).

Outliers

In order to obtain relevant parameter estimates we want to exclude outliers from the estimation. Some municipalities have extreme variable values in one or more years. This can either be due to some special characteristics or to artifacts in the dataset. Failure to remove important outliers may result in distorted parameter estimates. We use an outlier definition that expands on that of Aaberge and Langørgen (2003), Pedersen (2008), Langørgen, Pedersen and Aaberge (2010) and Kerimova (2011). All observations of Oslo are omitted when estimating because of its double status as both municipality and county. Such a status makes it difficult to identify which expenditures are associated to either municipality or county services. Some municipalities with traits such as being unusually rich, small or have large expenditures in some sector are also removed from all estimation. In addition, we remove municipalities with negative reported sector expenditures, huge budget deficits or surpluses, and abnormal real income growth or decline.

An overview of the outliers is included in appendix B

7.1 Modeling time heterogeneity

Estimating the model with multiplicative time dummies (model 1) is challenging in a number of ways. An obvious problem is that of computational costs. Expanding the panel by one year adds twelve new coefficients to be estimated, and the full data set requires more than 400 time dummies. This results in a curse of dimensionality where computation time grows exponentially with the time dimension. Another problem is identification. Without further restricting the base model, specifically the constant terms, some of the equations might lose identification when adding time dummies. It will also be difficult to know exactly what effects the time dummies are picking up. We can of cause rationalize that they at least contains real growth and sector prioritizations, but they will in practice not be exactly the same as the sector expenditure indices. This is also what we observe when estimating model 1.[9] Some of the sectors show time effects that are comparable with the sector specific relative expenditure indices $\tilde{S}_{it}$, but a few are either very large or very small. Such exaggerated time effects should influence the other parameter estimates of the model as well. In a single equation type model the large time interaction coefficients would lead to underestimation of the other parameters, and the converse for small time effects. Since we have multiple equations that are estimated simultaneously the effect on the parameter estimates will be more ambiguous. Still, it is obvious that the two methods used to handle the time heterogeneity in the panel data models is picking up much of the same variations.[10]

All in all, the method of removing the time heterogeneity with the sector expenditure index seems to produce estimates that are comparable to those we get with multiplicative time dummies. In addition we also get more degrees of freedom, easier computation and need fewer restrictions on the model specifications to ensure identification. This will allow us to estimate more advanced model specifications such as the dynamic models.

7.2 Discussion of parameter estimates

The following discussions will concentrate on the three models that use the sector expenditure deflators to handle time heterogeneity. These models will be estimated over the full panel with the extended specifications described in the start of the chapter. Each model is estimated with the same excluded outliers. The estimation procedure of all models produced approximately normal errors in each sector. The adjusted R^2 of model 2 shown in table 7.3 indicate that the model explain the variation of most sectors well. While the explanatory power of the other education sector and the infrastructure sectors are the not that high. These sectors generally contain several different services, and although the variables in these sectors explain some of the expenditure well they do not explain all the variation.

[9] See appendix C
[10] See appendix D

Table 7.3. Adjusted R-squared

Expenditure sector equation	Model 2	Model 3	Model 4
Administration sector..........	0,856	0,927	0,934
Primary school sector..........	0,740	0,953	0,954
Other education sector..........	0,490	0,759	0,762
Child care sector..........	0,854	0,968	0,969
Health care sector..........	0,569	0,824	0,824
Social assistance sector..........	0,605	0,860	0,861
Child protection sector..........	0,634	0,836	0,836
Care for the elderly and disabled sector..........	0,933	0,974	0,977
Culture sector..........	0,627	0,871	0,872
Municipal roads sector..........	0,337	0,622	0,622
Water supply and sanitation sector..........	0,544	0,860	0,862
Other infrastructure sector..........	0,466	0,791	0,795
Log liklihood	-178436	-93634	-91003,5

The high R^2 reported by the dynamic models are mostly a consequence of the use of a lagged dependent variable as an explanatory variable.

7.2.1 Marginal effects on the minimum required expenditures

A detailed description of the factors contributing to minimum required expenditure of each sector in their cross-section analysis on each of the years 2000 to 2008 can be found in Langørgen, Pedersen and Aaberge (2010). Kerimova (2011) also has a similar description.

Throughout the sectors, we observe somewhat large or inflated[11] parameter estimates in the two dynamic models. This effect will be the discussed in a later chapter, so the comments here will mainly be on the parameter estimates of the static model.

The **administration sector** expenditure includes costs related to political governance, control organs and other administration services. A certain minimum level of administration services must be maintained even in small municipalities. Then the cost pro capita should be higher in small municipalities than in larger ones. The inverse population size criterion is defined as 1000 divided by population. This means that the parameter estimate of this variable can be given the interpretation of millions of kroner in fixed sector costs. Or put differently, there are economies of scale in the sector.

[11] Inflated meaning larger absolute values.

Table 7.4. Administration sector

Effect on minimum required expenditure	Model 2	Model 3	Model 4
Constant term	2,04	2,41	2,42
	(61,32)	(22,91)	(19,79)
Constant term (change in 2001)	0,28	1,23	1,24
	(9,22)	(11,52)	(9,85)
Inverse population size	4,53	5,92	5,45
	(114,73)	(39,68)	(38,35)
Inverse population size (change in 2001)	1,01	0,90	1,19
	(22,64)	(5,49)	(7,65)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

That the municipality administration has large fixed costs is plausible. All the models estimate the fixed costs to be fairly large. The structural breaks should pick up an increase in administration costs in 2001 due to the change in accounting practices.

The **primary school sector** covers the children school and the youth school. Pupils in both schools levels influence sector expenditures since they increase the number of school spots that the municipalities must supply pro capita. The effect of children school population on the expenditure increases with the implementation of the school reform in 1997. Inverse population size is thought to pick up the economies of scale present in the sector due to small class sizes and small schools. The decrease in fixed costs in 2001 is assumed to pick up a transfer of administration costs to the administration sector due to the changed accounting regime.

Table 7.5. Primary school sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Population in elementary school age	36,91	59,82	58,79
	(37,29)	(29,24)	(27,52)
Population in elementary school age (change in 1997)	2,81	9,24	8,78
	(6,79)	(11,00)	(9,15)
Population 13-15 years of age	96,43	54,10	58,47
	(51,85)	(14,34)	(15,02)
Distance to centre of municipal sub-district	1,15	1,43	1,33
	(94,59)	(50,31)	(43,57)
Inverse population size	3,55	4,74	4,39
	(73,52)	(54,51)	(47,07)
Inverse population size (change in 2001)	-1,01	-2,28	-1,89
	(19,76)	(23,15)	(17,86)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

In model 2 the cost of pupils in youth school are much higher than that of a pupil in children school, but this difference is evened out in the two dynamic models.

The **other education sector** is made up from the expenditures of special schools, adult education, before and after school programs and music schools. Children in primary school age are assumed to influence the cost in most of these groups. Children with providers working full time are assumed to be more in need of services like after school programs. This effect is only included after 1990, which is when such programs started to become a common municipality service. Language training and other integration initiatives for refugees is assumed to influence the cost of adult education.

Table 7.6. Other education sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term (after 2000).........	-0,33	-1,00	-1,05
	(23,10)	(25,86)	(23,13)
Population in primary school age.........	4,60	6,07	5,93
	(32,63)	(13,85)	(12,34)
Children in child care age with full time working providers (after 1990).....	7,91	11,43	12,04
	(24,34)	(11,37)	(11,01)
Refugees living 5 years or less in Norway (after 1986).........	19,83	29,59	26,91
	(27,03)	(10,64)	(9,43)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

These parameter estimates all seem reasonable. Compared to the static model, the parameter estimates of the dynamic models are a little inflated. The constant term is included to pick up that more of the administration costs were transferred to the administration sector with the change in accounting practices in 2001.

The **child care sector** expenditure is influenced by children in child care age as well as groups of children with special needs. Such children are those with full time working providers or with a single provider. The coefficients of population in childcare age and children with providers working full time has been estimated over several segments. This is to facilitate a change in their relative explanatory values within the sector as child care has transitioned from a service for those with special needs to a general service.

Table 7.7. Child care sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Population in child care age (1983-1990)..	2,87	5,57	6,66
	(1,32)	(1,20)	(1,30)
Population in child care age (1991-1995)..	18,46	41,65	41,04
	(31,26)	(31,55)	(27,70)
Population in child care age (1996-2000)..	27,60	39,47	38,36
	(48,50)	(29,94)	(25,96)
Population in child care age (2001-2005)..	39,23	68,55	67,79
	(71,33)	(57,30)	(51,30)
Population in child care age (after 2005)...	45,29	85,79	86,24
	(78,75)	(68,08)	(62,74)
Children in child care age with full time working providers (1974-1982)....	136,87	275,53	257,78
	(8,44)	(6,77)	(5,62)
Children in child care age with full time working providers (1983-1990)....	101,75	222,33	213,43
	(11,67)	(11,79)	(10,34)
Children in child care age with full time working providers (after 1990).....	56,86	48,70	49,75
	(42,44)	(16,24)	(15,57)
Children in child care age with single provider..	10,53	26,64	22,85
	(4,94)	(5,87)	(4,84)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The parameter estimates of the static model seems sensible compared to those of model 1 and 2 estimated on shorter intervals, but the dynamic parameter estimates seems particularly inflated in this sector.

The **health care sector** mostly consists of the municipality health care service expenditures, but also covers some preventive programs. Distance to the center of the municipal sub-district explains extra costs associated with travel distance, while inverse population size explains costs of not being able to exploit economies of scale. For instance, some small municipalities need to compensate physicians for the small patient base. Small municipalities also need a certain minimum level of emergency care staff ready or on call. This will result in higher pro capita costs than in bigger municipalities which we can see in the inverse population criterion.

Table 7.8. Health care sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term	1,04	1,38	1,36
	(38,36)	(17,27)	(15,86)
Distance to centre of municipal sub-district	0,29	0,38	0,39
	(22,74)	(9,30)	(9,37)
Inverse population size	1,80	2,08	2,07
	(71,53)	(25,63)	(24,96)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The **social assistance sector** expenditure includes the costs from a number of programs. Unemployed are expected to increase the costs of job market programs. Transfers to families with insufficient means to cover living expenses and other in-kind transfers should be affected by the number of poor people living in the municipality. As of 1991 the central government has compensated the municipalities for refugees who have been living in the country five years or less, since these are thought to use a disproportionally more of social services. Refugees who have been living in the country more than five years are also thought to increase the costs of social assistance services in the municipalities as discussed in NOU (1996:1). Disablement pensioners and divorced/separated are also expected to contribute to the social assistance expenditures since they often are the beneficiaries of the in-kind transfers in this sector. A structural change has been added to divorced/separated as it is believed that this group was more vulnerable and less often employed before 1991, and thus explained relatively more of the sector expenditures.

Table 7.9. Social assistance sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Refugees living 5 years or less in Norway (from 1991)...............................	23,61	26,20	25,11
	(49,05)	(18,95)	(17,79)
Refugees living more than 5 years in Norway (from 1991)........................	15,58	15,87	15,26
	(13,62)	(4,22)	(3,93)
Divorced/separated 16-59 years..	16,66	36,11	36,34
	(35,14)	(26,71)	(25,36)
Divorced/separated 16-59 years (change 1991)...	-7,80	-27,71	-27,94
	(24,57)	(28,88)	(26,75)
Unemployed 16-59 years..	3,52	3,74	4,31
	(8,79)	(3,08)	(3,32)
Number of poor..	8,05	8,13	8,14
	(31,46)	(10,98)	(10,61)
Disablement pensioners 18-49 years of age..	7,53	9,63	8,92
	(10,48)	(4,63)	(4,09)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

Except for the effect from divorced/separated being high prior to 1991 these parameter estimates are sensible for all models.

The **child protection sector** has the operational responsibility of monitoring and preventing child abuse. The sector also administrates programs supporting and relieving at-risk families. The number of children in the municipality explains some of the variation in child protection expenditures. Serious child neglect often originates from social and economic problems, which can be indicated by children with a single provider and children from poor families.

Table 7.10. Child protection sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Population less than 16 years of age..	1,84	2,17	1,99
	(27,72)	(10,30)	(8,97)
Children less than 16 years of age with single provider...............................	19,19	23,61	23,41
	(42,13)	(16,83)	(16,00)
Poor children less than 16 years of age..	3,95	9,80	11,49
	(7,03)	(4,96)	(5,65)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The **long-term care sector** expenditures cover the operation of nursing homes, home care and ambulant nurses for the elderly and facilitated living for the disabled. The elderly are divided into different age groups since they often have needs that differ greatly, which mean they influence the minimum required costs differently. The disabled are included as of 1991 when the reform requiring municipalities to provide them with facilitated living arrangements was introduced. The distance to municipality sub-district center criteria pick up travel distance costs associated with home care and ambulant nurses, while the inverse population size describe costs from unutilized economies of scale.

Table 7.11. Long-term care sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Population less than 67 years of age..	3,46	4,53	4,64
	(30,17)	(14,21)	(13,60)
Population 67-79 years of age..	29,14	50,09	40,66
	(26,31)	(16,05)	(12,79)
Population 80-89 years of age (1974-1987)...	78,78	84,38	177,04
	(12,95)	(4,45)	(8,01)
Population 80-89 years of age (1988-1990)...	112,54	286,11	322,81
	(30,84)	(30,33)	(32,49)
Population 80-89 years of age (after 1990)..	78,26	39,71	64,16
	(32,76)	(5,46)	(9,29)
Population more than 89 years of age...	198,40	243,36	206,05
	(26,41)	(10,22)	(9,38)
Mentally disabled 16 years and above without grant (from 1991)..............	289,51	382,88	393,22
	(38,41)	(15,03)	(17,71)
Mentally disabled 16 years and above with grant (from 1991)....................	876,33	902,64	884,68
	(137,70)	(34,41)	(37,55)
Distance to centre of municipal sub-district..	0,81	1,03	0,80
	(25,39)	(11,45)	(9,31)
Inverse population size...	4,35	4,44	4,28
	(68,73)	(25,47)	(24,50)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The cost of population with age between 80-89 years old has several structural breaks. A break is added in 1988 to capture the increased costs of the elderly care reform. Then one in 1991, both since this group is expected to become less costly as population becomes healthier and because of the change in accounting practices. The parameter estimates from the static model seems to be sensible, but for some variables the dynamic models provide very large estimates.

The **culture sector** expenditures cover costs associated with cinemas, libraries, museums, sports, arts and religious purposes. The inverse population size criterion is the only included variable contributing to the minimum required expenditure. Until its inclusion in the block grant system in 1986 small municipalities got larger earmarked grants for culture purposes than other municipalities.

Table 7.12. Culture sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term	1,02	1,31	1,27
	(82,84)	(42,84)	(37,03)
Inverse population size	0,41	0,45	0,42
	(31,43)	(12,67)	(11,30)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The **municipal roads sector** expenditures include the costs of building and maintaining roads, as well as road safety work. The total length of municipal roads and amount of snowfall has been shown to increase the minimum required expenditures of roads. These factors should explain maintenance and snow removal costs.

Table 7.13. Municipal roads sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term	0,18	0,20	0,18
	(17,60)	(5,53)	(4,75)
Amount of snowfall	0,04	0,07	0,07
	(17,22)	(8,35)	(8,10)
Kilometers of municipal road	21,79	21,04	20,76
	(57,45)	(14,96)	(14,25)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The **water supply and sanitation sector** cover the costs of supplying water to the households in the municipality, as well as connecting them to a sewer system with purification plant. Advanced purification is obviously more expensive than simpler purification techniques. Expenditures in this sector have been found to increase with capacity of advanced purification, which is either biological purification, chemical purification or both. There are probably some fixed operational costs of running purification plants since they need to be staffed. We find that economies of scale are present in this sector as indicated by the inverse population size criterion.

Table 7.14. Water supply and sanitation sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term	1,18	1,40	1,40
	(91,31)	(51,94)	(46,18)
Capacity of advanced purification	0,47	0,54	0,52
	(40,03)	(17,12)	(14,92)
Inverse population size	0,44	0,52	0,50
	(28,75)	(16,49)	(15,14)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The **other infrastructure sector** consists of residential and commercial infrastructure, area planning and building services and, environment and waste management and fire and rescue services. The provision of many small services will naturally lead to economies of scale. The inverse population size criteria indicate the cost of not utilizing this effect. Municipal commercial activities were recorded in this sector to a much higher degree prior to the change in accounting practices in 1991 than after. This is why we do not include the effect of inverse population size in that period.

Table 7.15. Other infrastructure sector

Effect on minimun required expenditure	Model 2	Model 3	Model 4
Constant term	0,77	1,30	1,16
	(24,60)	(17,67)	(13,44)
Inverse population size (from 1991)	2,11	1,91	1,64
	(28,79)	(11,72)	(9,16)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

Overall, the three models produce parameter estimates which are in line with the costs we expect for the different groups. The static model produce estimates that are comparable with those of the two static models estimated on shorter intervals[12] in 7.1. and also with those of earlier versions of KOMMODE such as Langørgen, Pedersen and Aaberge (2010) and Kerimova (2010) The dynamic models also produce parameter estimates that often are comparable to those of the static model, although some of the parameters seem inflated.[13] This results in somewhat larger minimum required expenditures.[14] We will discuss the dynamic models more in chapter 7.3.

[12] See appendix C
[13] Inflated meaning larger absolute values.
[14] See appendix E

7.2.2 Marginal budget shares

Municipalities can freely allocate the remaining income after total minimum required expenditure is covered. This allocation is assumed to be influenced by three taste variables. The socialist share in local government council, average education and share living in densely populated areas.

Table 7.16 show that the socialist share in the local council is found to increase the municipal use of the disposable income in the administration sector, primary school, other education, child care, health care, child protection, long-term care and culture sectors. Of these, the long-term care sector, administration sector and primary school sector are particularly large, which are plausible focus areas for socialist parties. The only sectors that are affected significantly negative are other infrastructure sector and the net operating surplus. One possible reason for this may be that other infrastructure sector contains municipality owned/run businesses and other commercial activity. The socialist share also seems to strongly reduce the share of disposable income used in the net operating surplus sector.

Table 7.16. Effect of sosialist share in local council on marginal budget share by sector

	Model 2	Model 3	Model 4
Administration	0,12	0,12	0,07
	(9,58)	(9,58)	(6,13)
Primary school	0,13	0,13	0,08
	(11,34)	(11,34)	(7,25)
Other education	0,03	0,03	0,03
	(4,36)	(4,36)	(4,18)
Child Care	0,05	0,05	0,04
	(10,18)	(10,18)	(8,61)
Health care	0,06	0,06	0,05
	(5,57)	(5,57)	(5,06)
Social assistance	0,01	0,01	0,01
	(1,67)	(1,67)	(1,90)
Child protection	0,02	0,02	0,02
	(4,20)	(4,20)	(4,29)
Care for the elderly and disabled	0,19	0,19	0,12
	(9,01)	(9,01)	(6,01)
Culture	0,05	0,05	0,04
	(8,92)	(8,92)	(7,68)
Municipal roads	-0,01	-0,01	-0,01
	(0,90)	(0,90)	(1,02)
Water supply and sanitation	0,01	0,01	0,00
	(0,86)	(0,86)	(0,52)
Other infrastructure	-0,14	-0,14	-0,12
	(6,51)	(6,51)	(5,80)
Net operating surplus	-0,34	-0,45	-0,34

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The average share of socialists in the local council has varied between 40 and 45 percent up until 1996 when it fell to 37 percent. It was at a low point in 2000 with 36 percent but recovered somewhat to 39 percent in 2004.

The share of inhabitants living in densely populated areas increase the marginal share of disposable income used in social assistance, culture, water supply and sanitation and other infrastructure sectors as shown in table 7.17. The administration sector, primary education sector, care for the elderly and disabled sector and child care sector is found to be down prioritized in urban municipalities. Dense settlement also increase the net operating surplus.

Table 7.17. Effect of urban settlement on marginal budget share by sector

	Model 2	Model 3	Model 4
Administration	-0,07	-0,07	-0,07
	(9,56)	(9,56)	(10,38)
Primary school	-0,07	-0,07	-0,07
	(11,63)	(11,63)	(11,34)
Other education	0,01	0,01	0,01
	(1,34)	(1,34)	(1,45)
Child Care	-0,02	-0,02	-0,01
	(6,07)	(6,07)	(5,25)
Health care	0,00	0,00	0,00
	(0,56)	(0,56)	(0,24)
Social assistance	0,02	0,02	0,02
	(5,26)	(5,26)	(5,28)
Child protection	0,00	0,00	0,00
	(0,52)	(0,52)	(0,46)
Care for the elderly and disabled	-0,10	-0,10	-0,07
	(9,02)	(9,02)	(6,86)
Culture	0,01	0,01	0,02
	(4,32)	(4,32)	(5,16)
Municipal roads	0,00	0,00	0,00
	(1,17)	(1,17)	(1,08)
Water supply and sanitation	0,03	0,03	0,03
	(9,44)	(9,44)	(9,24)
Other infrastructure	0,09	0,09	0,08
	(7,70)	(7,70)	(6,98)
Net operating surplus	0,03	0,07	0,08

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The share of people living in densely populated areas has increased throughout the estimation period. From a share close to 41 percent in 1974 to 51 percent in 2008.

Average education level positively influence the marginal budget share of the administration, primary school, child care, health care, social assistance, child protection, long-term care, culture and water supply and sanitation sectors. The primary school sector and long-term care are the sectors most prioritized by higher average education.Educated people will probably value education and the administration sector often employs highly educated people. Both of which can explain the positive increase in the primary school and the administration sector. The only negative effect is on net operating surplus.

Table 7.18. Effect of average education on marginal budget share by sector

	Model 2	Model 3	Model 4
Administration	0,03	0,03	0,02
	(7,13)	(7,13)	(5,33)
Primary school	0,04	0,04	0,03
	(11,16)	(11,16)	(8,17)
Other education	0,00	0,00	0,00
	(1,06)	(1,06)	(0,87)
Child Care	0,02	0,02	0,01
	(10,09)	(10,09)	(8,91)
Health care	0,02	0,02	0,02
	(5,63)	(5,63)	(5,25)
Social assistance	0,02	0,02	0,02
	(8,49)	(8,49)	(8,35)
Child protection	0,01	0,01	0,01
	(8,97)	(8,97)	(8,64)
Care for the elderly and disabled	0,04	0,04	0,03
	(5,24)	(5,24)	(4,96)
Culture	0,03	0,03	0,03
	(16,78)	(16,78)	(15,47)
Municipal roads	0,00	0,00	0,00
	(2,29)	(2,29)	(2,07)
Water supply and sanitation	0,02	0,02	0,02
	(12,47)	(12,47)	(11,67)
Other infrastructure	0,00	0,00	-0,01
	(0,04)	(0,04)	(1,30)
Net operating surplus	-0,18	-0,20	-0,18

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

The average education has been steadily increasing. From an average of 0.88 extra years of schooling in excess of 9 years in 1974, to 2.78 years in 2008.

Across all three models we find similar effects on the marginal budget shares. We also find that most effects match earlier results in Langørgen, Pedersen and Aaberge (2010) and Kerimova (2011). Some notable differences are that they found negative effects from average education on the administration sector and the primary school sector, which is the opposite of the results presented here.[15] The strong time trend in both the average education variable and the urban settlement variable may cause problems since they are likely to be spuriously correlated with other variables that have time trends. One possible solution is to instead transform these variables to deviations from yearly mean.

7.3 Dynamic effects

An important reason for creating a dynamic model is to observe relationships that are hidden in a cross-section model. The most important dynamic relation in a partial adjustment model is the adjustment speed. Most municipal services are labor intensive. Strong worker rights means that employees rarely are fired, so shifting resources around in municipal service sectors usually mean hiring or relocating (Langørgen et al. (2010)). Such processes can be slow and expensive depending on external factors such as the business cycle or other municipal characteristics. We will analyze the results from different specifications of a heterogeneous adjustment speed and compare the results with earlier research. It will also be important to analyze the net operating surplus sector which has a quasi-dynamic form.

7.3.1 Net operating surplus sector

In the net operating surplus sector it is not meaningful to talk about the minimum required expenditure in the same sense as in the other sectors. The marginal share of disposable income, the allocation of income growth, minimum required expenditure and net operating surplus from last period should all be considered together. Equation (7.1) describes the identity relation of the net operating sector.[16]

$$u_{0t} = \lambda\left(\alpha_{0t} + \beta_0(y_t - \alpha_t)\right) + (1-\lambda)\left[u_{0,t-1} + \delta_0(y_t - y_{t-1})\right] \tag{7.1}$$

If we take a look at the parameter estimates from the minimum required net operating surplus sector equation (6.9) we recognize the strict budgetary rules described in 5.3.

[15] The negative effect on primary education is not significant for all the the years in in Langørgen, Pedersen and Aaberge (2010)

[16] Sector 0 is the net operating surplus.

Budget deficits in previous years lead to a strengthening of the budgetary balance in the current year.

Table 7.19. Net operating surplus sector

	Model 3	Model 4
Constant term	-2,11	-2,30
	(14,09)	(12,92)
Negative budget balance 1 year ago	-0,60	-0,66
	(8,19)	(10,14)
Negative budget balance 1 year ago (change 2001)	-0,32	-0,27
	(3,82)	(3,39)
Negative budget balance 2 years ago	-0,57	-0,70
	(2,68)	(3,45)
Negative budget balance 2 years ago (change 2001)	-0,34	-0,09
	(1,31)	(0,33)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

As can be seen in table 7.19. the revision of the budget rules in 2001 lead to a further strengthening of the response after deficits.

The marginal budget share of the municipalities also contributes to this sector. The average marginal share for the net operating surplus over all units and time periods is more than 25 percent of discretionary income. This marginal share has a downward trend due to the negative influence from average education (see table 7.18), which is steadily increasing over time.

Real income growth of the municipalities would lead to an overestimate of the adjustment speed if unaccounted for. To control for this and to satisfy the budget constraint we added the deltas in (6.5). Sectors with significantly positive deltas can be interpreted as being used as budget balancing items. Such sectors expenditures are more easily reduced if the budget needs tightening and increased when extra funds are available.

Table 7.20. Allocation of real income growth

	Model 3	Model 4
Administration	-0,01	0,00
	(4,54)	(3,39)
Primary school	0,00	0,00
	(3,88)	(2,99)
Other education	0,00	0,00
	(1,50)	(1,22)
Child Care	0,00	0,00
	(2,03)	(2,64)
Health care	0,01	0,01
	(6,00)	(6,49)
Social assistance	0,00	0,00
	(2,55)	(2,77)
Child protection	0,00	0,00
	(1,46)	(1,09)
Long-term care	0,03	0,02
	(17,44)	(11,60)
Culture	0,00	0,00
	(2,45)	(2,56)
Municipal roads	0,00	0,00
	(5,13)	(5,04)
Water supply and sanitation	0,00	0,00
	(1,83)	(1,93)
Other infrastructure	0,09	0,09
	(56,07)	(55,28)
Net operating surplus	0,87	0,88

T-values reported in parenthesis. Coefficients represent shares of total real income growth.

The two models produce pretty similar estimates of the deltas. Aside from the net operating surplus only the health care sector, long-term care sector and other infrastructure sector has significant positive results. While the first two effects are very small, other infrastructure has a somewhat larger delta of 0.09. By estimating the dynamic models on different time segments, the delta for other infrastructure sector seems to be high throughout the period. This sector consists of many smaller services, often of a monitoring or preparedness type. Cutting costs in such services may prove politically easier than other services that impact the welfare of the citizens more directly.

Since (6.7) holds, this means that the share of real income growth that is distributed into the net operating surplus sector is 0.87 in model 3 and 0.88 in model 4. These results simply explain that most of real growth in municipal income, positive or negative, directly impacts the net operating surplus sector.

7.3.2 Heterogeneous adjustment speed

The starting point for further analysis is to examine the estimate of the constant adjustment speed of the two dynamic models. While many of the parameters estimates seem to differ between the two models, the adjustment speed estimates do not diverge that much. By only estimating the constant term of (6.12) we get 0.209 in model 3 and 0.206 in model 4.

Now we want to see how the results of this model holds up to Borge and Rattsø (1995). They found that small municipalities with less than 5000 inhabitants responded significantly faster than larger municipalities to exogenous changes. The following discussion will concentrate on the parameter estimates of model 3.

Table 7.21. Effects on adjustment speed

	Model 3	Model 4
Adjustment speed..	0,194	0,190
	(180,20)	(176,18)
Change in adjustment speed (population<5000)..	0,022	0,022
	(19,91)	(19,75)

We find the adjustment speed to be 0.194 for large municipalities and 0.216 for small municipalities, meaning that small municipalities adjust faster. This effect has the same direction as found by Borge and Rattsø (1995). They found average adjustment speeds of 0.10 for large and 0.14 for small municipalities, but they used an entirely different model setup so the effects are not directly comparable. However, when estimating the models over the same time span (1984-1987) as used by Borge and Rattsø (1995) the results are much closer. More precisely we get an adjustment speed of 0.127 for the large and 0.162 for the small municipalities.

Since we have a large panel data set we can model more complicated relationships. One apparent extension is to allow the adjustment speed to change over time. By replacing the constant term with three different constants for the time segments 1974-1990, 1991-2000 and 2001-2008 we also avoid any problems caused by different accounting regimes.

Table 7.22. Effects on adjustment speed

	Model 3	Model 4
Adjustment speed (1974-1990)..	0,170	0,166
	(144,80)	(141,11)
Adjustment speed (1991-2000)..	0,192	0,190
	(143,83)	(142,13)
Adjustment speed (after 2000)...	0,237	0,228
	(169,80)	(163,03)
Change in adjustment speed (population<5000)..	0,022	0,022
	(19,85)	(19,65)

The adjustment speed is clearly increasing over time. Municipalities adjust on average 6.7 percent more towards equilibrium after 2000 than before 1991, and 4.5 percent more than between 1991 and 2000. Large municipalities continue to be more sluggish in their reallocation response.

Municipality size is clearly an important factor for explaining reallocation dynamics. The influence of size can be made more nuanced by subdividing municipalities into finer size categories. These groups are; smaller than 2000 inhabitants; between 2000 and 5000 inhabitants; between 5000 and 20000 inhabitants; leaving municipalities with a population of more than 20000 as the base group.

Table 7.23. Effects on adjustment speed

	Model 3	Model 4
Adjustment speed (1974-1990)..	0,161	0,158
	(48,77)	(46,20)
Adjustment speed (1991-2000)..	0,184	0,181
	(54,99)	(52,76)
Adjustment speed (after 2000)...	0,228	0,219
	(67,94)	(63,18)
Change in adjustment speed (tiny; population<2000).......................................	0,046	0,044
	(13,78)	(12,90)
Change in adjustment speed (small; 2000 < population < 5000)........................	0,020	0,021
	(5,94)	(6,08)
Change in adjustment speed (medium; 5000 < population < 20000)..................	0,008	0,007
	(2,28)	(2,12)

These parameter estimates confirms the results commented above. Average adjustment speed increase over time, and small municipalities adjust faster than larger ones. But what is shown here is that the size trend is pervasive through the different groups. Large municipalities on average exhibit stronger inertia than medium sized municipalities, which in turn are slower than small municipalities. Municipalities with less than 2000 inhabitants have the highest adjustment speed where 4.6 percent more of the desired change in allocation is implemented in the first year than in the base group.

Some suggested reasons for this finding can be that larger municipalities have organizational structures that are more complex than smaller ones. Longer chains of command can create a delay between an observed change and the decision to adjust.

7.3.3 Dynamic bias

As mentioned earlier the estimated adjustment speed parameters in the dynamic models did not diverge much. Model 3 had an adjustment speed that was 0.3 percent higher than that of model 4. While the difference is statistically significant, it is of no economic significance. But this still runs counter to our expectations given the results from chapter 3.2.1. Table 7.24 shows that the estimated parameters in the error terms (6.14) of model 4 are positive for all sectors. Positive autocorrelation coefficients in the error term and positive adjustment speed should have resulted in an asymptotic negative bias in the adjustment speed estimate produced by model 3. This is the opposite of what we observe.

Table 7.24 Autocorrelation coefficient in error term of model 4

Administration	0,31
	(96,60)
Primary school	0,17
	(35,67)
Other education	0,11
	(19,62)
Child Care	0,14
	(22,84)
Health care	0,08
	(15,78)
Social assistance	0,09
	(13,72)
Child protection	0,06
	(12,89)
Care for the elderly and disabled	0,38
	(88,12)
Culture	0,08
	(12,63)
Municipal roads	0,05
	(9,68)
Water supply and sanitation	0,09
	(12,72)
Other infrastructure	0,14
	(30,95)

We observe almost systematically larger absolute parameter estimates in the dynamic model versions than in the static. This “inflation effect” is strong in some sectors and hardly present in some. This discrepancy between the dynamic and static estimates was not expected, and we will discuss a few of the inquiries that have been made to uncover the reason for it.

This could be a result of multicorrelation between the explanatory variables and the lagged dependent variable, which would explain why the effect is different across the sectors. If indeed the equilibrium parameter estimates are overestimated, then the adjustment speed will be underestimated. By fixing the adjustment speed parameter to $\lambda = 0.3$, $\lambda = 0.5$ and $\lambda = 0.9$ we find that the parameter values of model 3 gradually approaches those of model 2. If the inflation effect was due to multicorrelation we could expect the parameter estimates to approach expected values when the adjustment speed parameter was set a little higher.

The partial adjustment model estimated by Kerimova (2011) on the years 2001-2008 also seems to suffer from the same problem. Compared to the other models the parameters estimates of the other models are inflated. We have also estimated the models on shorter time segments, and the effect is still there.

A robustness analysis has been performed by running five estimations where either 50 percent, 75 percent or 90 percent of the observations were randomly removed. We find the parameter estimates of model 3 to be stable in all the 15 estimations, even with only 10% of the original observations.

Numerous other approaches and misspecification tests[17] has been applied in order to uncover the cause of the discrepancy, but none has been found. We leave this issue to be investigated by future studies in this topic.

[17] Local FIML optima, alternative error specifications, sector specific adjustment speed coefficients and various structural breaks.

8 Concluding Remarks

Comparisons between short period versions of the two static models using either time dummies or sector specific expenditure deflators to handle time heterogeneity suggest that the latter method has certain favorable attributes. Other than producing reasonable parameter estimates, it is also less computationally costly than the time dummy approach as well as less likely to be having problems with identification. A model specification with several structural breaks is proposed to accommodate changes in the parameters due to institutional or social changes. Three models are estimated over the full period. One static model, one partial adjustment model without and one partial adjustment model with autocorrelated errors. The static model produces parameter estimates that are comparable to those obtained on shorter segments. The dynamic models produce estimates that can seem to be inflated compared to the static models. We have made many attempts to uncover the reason for this difference, but it has proven to be elusive.

In our analysis of the dynamic model results we found that net operational deficits in the preceding years leads to a strengthening of the net operational surplus in the current year. This effect is strengthened further with the 2001 revision of the law of municipalities and the introduction of the ROBEK-list. By estimating a heterogeneous adjustment speed relation we found the inertia of large municipalities to be greater than that of smaller ones. This confirms earlier research by Borge and Rattsø (1995).

Further research into this topic should first of all investigate the reason behind the discrepancy between the static and dynamic results. To solve this will certainly reveal interesting information about the dynamic relationships of municipal spending. More work should also be applied to fine tuning the model specifications and the structural changes, and thereby further reduce misspecification in the models. Especially some inquiry into an alternative setup for the marginal budget shares could prove to be worthwhile. Last, a natural extension of the model would be to examine the omitted variable bias caused by unit heterogeneity by using region fixed effects as proposed by Kerimova (2011). The much larger time dimension in this panel data set should produce better estimates on these fixed effects.

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Appendix A: Index values

Table A.1. Index values for sector specific expenditure and municipal consumption

Year	S_{100}	S_{210}	S_{220}	S_{300}	S_{400}	S_{510}	S_{520}	S_{600}	S_{700}	S_{810}	S_{820}	S_{830}	P
1972	0,033	0,071	0,039	0,002	0,042	0,044	0,012	0,013	0,043	0,134	0,038	0,169	0,116
1973	0,038	0,077	0,042	0,002	0,047	0,051	0,014	0,015	0,048	0,141	0,041	0,190	0,126
1974	0,043	0,086	0,052	0,003	0,056	0,057	0,017	0,018	0,054	0,152	0,049	0,216	0,143
1975	0,053	0,102	0,063	0,005	0,082	0,060	0,019	0,022	0,067	0,183	0,060	0,254	0,161
1976	0,060	0,119	0,072	0,008	0,105	0,060	0,026	0,029	0,081	0,218	0,070	0,300	0,181
1977	0,070	0,134	0,088	0,011	0,083	0,063	0,029	0,030	0,101	0,254	0,085	0,348	0,199
1978	0,080	0,150	0,098	0,016	0,087	0,079	0,031	0,035	0,121	0,290	0,100	0,396	0,217
1979	0,087	0,158	0,102	0,020	0,098	0,090	0,036	0,040	0,135	0,284	0,116	0,424	0,224
1980	0,096	0,176	0,117	0,025	0,069	0,103	0,036	0,042	0,198	0,307	0,134	0,455	0,244
1981	0,114	0,197	0,131	0,033	0,089	0,082	0,042	0,051	0,233	0,334	0,151	0,503	0,270
1982	0,132	0,224	0,145	0,041	0,108	0,104	0,050	0,059	0,266	0,361	0,174	0,584	0,300
1983	0,150	0,243	0,161	0,050	0,100	0,146	0,053	0,070	0,302	0,397	0,194	0,670	0,323
1984	0,165	0,259	0,178	0,057	0,171	0,187	0,066	0,077	0,332	0,400	0,214	0,744	0,344
1985	0,183	0,283	0,187	0,064	0,221	0,215	0,071	0,086	0,362	0,443	0,237	0,836	0,365
1986	0,208	0,295	0,194	0,075	0,239	0,262	0,088	0,099	0,396	0,470	0,268	0,934	0,395
1987	0,252	0,328	0,227	0,096	0,263	0,351	0,103	0,115	0,451	0,551	0,299	1,002	0,437
1988	0,275	0,346	0,266	0,117	0,290	0,446	0,109	0,234	0,472	0,535	0,326	1,077	0,462
1989	0,291	0,360	0,294	0,138	0,315	0,508	0,113	0,247	0,486	0,518	0,350	1,085	0,481
1990	0,297	0,371	0,316	0,160	0,340	0,550	0,131	0,264	0,511	0,531	0,377	1,132	0,494
1991	0,367	0,378	0,441	0,186	0,367	0,538	0,183	0,346	0,612	0,582	0,394	0,495	0,508
1992	0,388	0,386	0,519	0,212	0,392	0,569	0,232	0,365	0,634	0,581	0,416	0,546	0,516
1993	0,390	0,390	0,590	0,239	0,421	0,599	0,265	0,376	0,661	0,583	0,432	0,606	0,522
1994	0,413	0,400	0,666	0,257	0,438	0,632	0,273	0,391	0,676	0,622	0,458	0,635	0,532
1995	0,437	0,411	0,725	0,275	0,454	0,672	0,292	0,417	0,697	0,638	0,497	0,643	0,552
1996	0,441	0,436	0,778	0,299	0,484	0,672	0,317	0,446	0,720	0,634	0,527	0,619	0,571
1997	0,462	0,477	0,833	0,310	0,512	0,631	0,337	0,470	0,745	0,661	0,570	0,598	0,590
1998	0,498	0,559	0,934	0,323	0,566	0,610	0,367	0,519	0,783	0,674	0,602	0,647	0,622
1999	0,489	0,605	0,956	0,341	0,612	0,636	0,396	0,567	0,829	0,712	0,680	0,648	0,644
2000	0,472	0,658	0,988	0,366	0,662	0,684	0,433	0,615	0,865	0,736	0,711	0,631	0,677
2001	0,818	0,711	0,693	0,389	0,695	0,698	0,610	0,601	0,719	0,782	0,791	0,678	0,724
2002	0,670	0,761	0,780	0,439	0,754	0,793	0,670	0,671	0,759	0,798	0,829	0,675	0,758
2003	0,824	0,813	0,812	0,494	0,784	0,868	0,706	0,698	0,784	0,791	0,842	0,697	0,798
2004	0,805	0,821	0,836	0,552	0,787	0,855	0,750	0,732	0,796	0,786	0,881	0,762	0,821
2005	0,793	0,850	0,851	0,617	0,806	0,919	0,800	0,754	0,806	0,808	0,887	0,806	0,845
2006	0,842	0,898	0,884	0,739	0,854	0,942	0,849	0,826	0,876	0,911	0,941	0,834	0,883
2007	0,936	0,951	0,938	0,860	0,917	0,935	0,920	0,900	0,944	0,979	0,925	0,895	0,928
2008	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Administration sector (100), primary school sector (210), other education (220), child care (300), health care (400), social assistance (510), child protection (520), long-term care (600), culture sector (700), municipal roads sector (810), water supply and sanitation sector (820), other infrastructure (830).

Appendix B: Outlier definitions

An observation of a municipality in time is labeled an outlier if either one the following conditions is satisfied. It is one of the permanent outliers, it has negative reported expenditures or it violates some rules restricting the allowed values of the net operating surplus and the real growth in income.

Table B.1. Permanent outliers

Excluded municipality		Reason for exclusion
(0301)	Oslo	County and municipality
(0428)	Trysil	Large infrastructure expenditures
(0434)	Engerdal	Large other education expenditures
(0941)	Bykle	Rich municipality
(1046)	Sirdal	Rich municipality
(1129)	Forsand	Rich municipality
(1151)	Utsira	Very small municipality
(1232)	Eidfjord	Rich municipality
(1252)	Modalen	Small and rich municipality
(1418)	Balestrand	Mix-up in municipal accounts
(1421)	Aurland	Rich municipality
(1665)	Tydal	Rich municipality
(1834)	Lurøy	Long travel distances
(1836)	Rødøy	Long travel distances
(1911)	Kvæfjord	Mix-up in municipal accounts
(2027)	Nesseby	Large culture expenditures

The rules for the net operating surplus are:

- Net operating surplus cannot be greater than 80% of the income of the municipality.
- Net operating deficit cannot be larger than 20% of the income of the municipality.

The rules for the real growth in income are:

- Real income growth cannot be greater than $1/3$ of the income.
- Real income growth cannot be less than $-1/2$ of the income.

Table B.2. Overview of number and decomposition of outlier reason

year	Total outliers	Fixed outliers	Negative reported expenditures	Large absolute net operating surplus	Large absolute real income growth
1972	43	15	20	6	4
1973	36	15	15	7	0
1974	25	15	9	1	3
1975	47	15	26	9	7
1976	38	15	15	7	5
1977	50	16	30	7	2
1978	47	16	32	4	2
1979	52	16	33	8	2
1980	83	16	66	4	1
1981	73	16	58	2	3
1982	55	16	43	1	1
1983	44	16	30	2	0
1984	33	16	17	1	3
1985	31	16	15	1	2
1986	36	16	23	0	0
1987	30	16	14	2	0
1988	24	16	9	2	1
1989	20	16	5	0	0
1990	25	16	7	0	3
1991	19	16	2	0	3
1992	22	16	6	1	0
1993	21	16	3	2	3
1994	18	16	1	0	1
1995	19	16	4	0	0
1996	20	16	4	1	2
1997	27	16	11	2	2
1998	25	16	8	1	1
1999	26	16	12	0	0
2000	28	16	13	0	0
2001	20	16	5	1	1
2002	25	16	8	4	4
2003	24	16	6	3	5
2004	21	16	4	1	2
2005	23	16	8	1	1
2006	21	16	6	1	1
2007	26	16	5	6	1
2008	25	16	5	7	1

Observations may satisfy more than one reason for being labeled an outlier, so total outliers are not the sum of the outlier groups.

Appendix C: Parmeter estimates - short segments

Table C.1. Parameter estimates – model 1

Sector	Time period	1974-1982	1983-1990	1991-2000	2001-2008
Budget surplus	Constant term	-2,30	-1,47	-1,62	-1,94
		(4,99)	(3,94)	(10,36)	(10,39)
	Real growth in municipal income	1,67	0,57	0,55	0,53
		(12,09)	(10,34)	(32,54)	(38,44)
Administration	Constant term	1,08	1,37	1,38	2,00
		(34,81)	(26,43)	(18,89)	(14,55)
	Inverse population size	1,76	2,95	2,95	5,09
		(61,63)	(65,23)	(44,53)	(49,65)
Primary school	Population in elementary school age	20,69	27,37	42,54	49,92
		(14,10)	(14,16)	(22,19)	(28,46)
	Population 13-15 years of age	69,05	77,18	94,00	75,64
		(22,67)	(21,56)	(22,30)	(21,25)
	Distance to centre of municipal sub-district	0,88	0,92	0,80	1,20
		(51,94)	(48,57)	(32,57)	(35,02)
	Inverse population size	3,01	2,87	1,69	2,30
		(34,97)	(32,30)	(18,11)	(30,33)
Other education	Population in primary school age	3,03	5,06	2,83	1,34
		(11,52)	(22,72)	(4,49)	(3,76)
	Children in child care age without full time working providers	-	-	16,84	8,99
		-	-	(10,94)	(12,64)
	Refugees living 5 years or less in Norway	-	6,94	14,35	33,66
		-	(5,25)	(5,66)	(25,69)
Child Care	Population in child care age	-	2,00	6,39	39,07
		-	(2,76)	(5,48)	(29,20)
	Children in child care age without full time working providers	31,32	36,81	59,60	78,46
		(27,62)	(15,84)	(16,67)	(30,49)
	Children in child care age with single provider	11,76	-0,02	2,84	9,03
		(9,94)	(0,01)	(0,71)	(2,17)
Health care	Constant term	0,31	0,77	1,00	0,97
		(3,42)	(12,84)	(15,50)	(13,85)
	Distance to centre of municipal sub-district	0,00	0,18	0,32	0,38
		(0,12)	(6,57)	(13,08)	(15,43)
	Inverse population size	0,38	1,13	1,20	1,89
		(4,78)	(19,73)	(18,44)	(37,42)
Social assistance	Refugees living 5 years or less in Norway	-	-	12,22	45,13
		-	-	(12,00)	(25,89)
	Refugees living more than 5 years in Norway	-	-	30,51	16,53
		-	-	(10,46)	(7,69)
	Divorced/separated 16-59 years	11,95	28,01	10,20	4,40
		(16,56)	(25,06)	(12,06)	(5,26)
	Unemployed 16-59 years	0,27	-0,30	5,52	8,04
		(0,36)	(0,24)	(6,18)	(5,37)
	Number of poor	1,34	5,64	4,87	9,93
		(6,76)	(8,73)	(8,35)	(12,73)
	Disablement pensioners 18-49 years of age	0,78	5,16	11,57	7,76
		(1,26)	(2,36)	(8,37)	(4,51)
Child protection	Population less than 16 years of age	0,14	0,42	1,41	1,75
		(3,10)	(6,29)	(13,82)	(6,99)
	Children less than 16 years of age with single provider	0,78	7,70	8,79	17,02
		(1,27)	(10,47)	(8,30)	(11,11)
	Poor children less than 16 years of age	2,70	-0,54	4,36	10,42
		(4,70)	(0,62)	(3,54)	(5,48)

Long-term care	Population less than 67 years of age...	0,30	1,02	2,41	2,88
		(2,27)	(5,06)	(9,59)	(8,69)
	Population 67-79 years of age..	3,12	17,81	27,21	35,28
		(2,36)	(8,10)	(11,00)	(11,04)
	Population 80-89 years of age..	51,16	80,32	78,40	62,21
		(12,10)	(11,97)	(14,11)	(11,34)
	Population more than 89 years of age...	38,14	100,41	182,35	233,42
		(3,07)	(4,68)	(9,91)	(15,49)
	Mentally disabled 16 years and above without grant....................	-	-	279,19	242,61
		-	-	(17,90)	(13,21)
	Mentally disabled 16 years and above with grant.........................	-	-	929,79	772,02
		-	-	(68,72)	(34,64)
	Distance to centre of municipal sub-district................................	0,08	0,33	0,42	1,11
		(2,67)	(6,16)	(6,41)	(15,13)
	Inverse population size...	1,27	3,84	3,13	2,67
		(19,55)	(35,10)	(18,71)	(15,70)
Culture	Constant term..	0,93	1,02	1,10	0,84
		(30,61)	(18,99)	(16,69)	(12,51)
	Inverse population size...	0,31	0,14	0,12	0,61
		(8,38)	(2,95)	(2,82)	(15,72)
Municipal roads	Constant term..	0,13	0,07	0,11	0,17
		(2,24)	(2,22)	(5,40)	(4,30)
	Amount of snowfall..	0,03	0,07	0,08	0,09
		(2,87)	(10,02)	(17,04)	(8,10)
	Kilometers of municipal road...	27,73	27,56	22,41	23,89
		(14,57)	(22,43)	(28,40)	(20,35)
Water supply and sanitation	Constant term..	0,70	0,88	1,31	1,07
		(21,24)	(26,73)	(45,00)	(18,23)
	Capacity of advanced purification..	0,12	0,31	0,53	0,64
		(6,21)	(13,35)	(21,14)	(16,89)
	Inverse population size...	-0,11	-0,05	0,12	0,51
		(2,77)	(1,01)	(3,32)	(9,12)
Other infrastructure	Constant term..	-1,01	0,63	1,01	1,26
		(2,83)	(1,89)	(9,08)	(8,05)
	Inverse population size...	-	-	2,08	1,62
		-	-	(17,35)	(14,62)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

Table C.2. Parameter estimates – model 2

Sector	Time period	1974-1982	1983-1990	1991-2000	2001-2008
Budget surplus	Constant term..	-1,07	-0,69	-2,13	-1,66
		(3,23)	(2,35)	(14,24)	(10,44)
	Real growth in municipal income...	1,81	0,48	0,53	0,54
		(13,68)	(9,99)	(32,65)	(39,96)
Administration	Constant term..	2,51	2,09	1,35	1,85
		(43,14)	(33,55)	(16,15)	(18,38)
	Inverse population size...	3,65	4,43	3,78	4,42
		(68,78)	(71,31)	(52,90)	(52,66)
Primary school	Population in elementary school age..	28,44	32,89	22,92	49,36
		(15,61)	(14,58)	(13,82)	(34,10)
	Population 13-15 years of age..	92,86	93,14	132,10	69,28
		(24,12)	(22,77)	(35,79)	(21,37)
	Distance to centre of municipal sub-district................................	1,19	1,16	0,78	1,14
		(54,92)	(53,46)	(29,64)	(38,34)
	Inverse population size...	4,06	3,70	1,54	2,19
		(37,70)	(34,70)	(16,47)	(30,27)
Other education	Population in primary school age...	6,01	6,37	1,50	2,32
		(16,24)	(27,48)	(3,59)	(6,84)
	Children in child care age without full time working providers....	-	-	9,75	7,57
		-	-	(9,84)	(10,46)
	Refugees living 5 years or less in Norway....................................	-	14,49	10,27	36,73
		-	(7,68)	(6,27)	(35,73)

Child Care	Population in child care age..	-	4,43	3,60	35,55
		-	(2,38)	(2,33)	(31,58)
	Children in child care age without full time working providers....	238,29	107,05	49,65	84,46
		(30,57)	(17,56)	(14,50)	(36,53)
	Children in child care age with single provider............................	97,68	-10,94	8,27	5,99
		(11,74)	(1,70)	(1,53)	(1,51)
Health care	Constant term..	0,89	1,03	0,70	0,90
		(7,93)	(13,20)	(12,09)	(16,37)
	Distance to centre of municipal sub-district................................	0,00	0,25	0,29	0,33
		(0,06)	(6,93)	(14,18)	(16,27)
	Inverse population size...	0,45	1,54	1,15	1,68
		(3,29)	(23,10)	(20,93)	(40,70)
Social assistance	Refugees living 5 years or less in Norway....................................	-	-	14,58	40,50
		-	-	(15,23)	(33,87)
	Refugees living more than 5 years in Norway.............................	-	-	26,70	15,86
		-	-	(9,11)	(8,07)
	Divorced/separated 16-59 years..	39,46	24,56	10,68	4,36
		(18,41)	(25,23)	(12,36)	(5,91)
	Unemployed 16-59 years...	-10,75	0,07	7,67	4,85
		(4,11)	(0,07)	(9,17)	(4,18)
	Number of poor..	8,87	5,37	5,85	9,44
		(15,74)	(9,62)	(9,68)	(14,48)
	Disablement pensioners 18-49 years of age................................	4,31	3,89	11,72	7,23
		(1,71)	(1,97)	(7,73)	(4,78)
Child protection	Population less than 16 years of age...	0,71	1,64	2,20	1,61
		(2,95)	(7,95)	(14,46)	(7,77)
	Children less than 16 years of age with single provider...............	7,53	23,58	12,16	15,32
		(2,34)	(9,98)	(7,55)	(11,11)
	Poor children less than 16 years of age.......................................	13,05	-2,96	8,21	7,39
		(4,54)	(1,00)	(4,48)	(4,86)
Long-term care	Population less than 67 years of age...	2,01	1,94	1,68	3,01
		(3,17)	(5,66)	(6,47)	(10,02)
	Population 67-79 years of age..	15,18	30,46	23,52	32,57
		(2,23)	(8,00)	(9,83)	(11,04)
	Population 80-89 years of age..	262,90	152,97	94,42	61,34
		(12,28)	(12,95)	(16,73)	(12,31)
	Population more than 89 years of age..	180,45	200,88	195,57	223,30
		(2,86)	(5,36)	(10,36)	(15,72)
	Mentally disabled 16 years and above without grant....................	-	-	311,22	233,26
		-	-	(20,93)	(13,67)
	Mentally disabled 16 years and above with grant..........................	-	-	969,84	734,68
		-	-	(88,45)	(36,23)
	Distance to centre of municipal sub-district................................	0,41	0,63	0,39	1,07
		(2,54)	(6,56)	(5,63)	(15,46)
	Inverse population size...	6,75	7,22	3,32	2,59
		(20,74)	(37,67)	(19,19)	(16,26)
Culture	Constant term..	1,05	0,87	0,67	0,82
		(40,84)	(25,71)	(18,25)	(16,59)
	Inverse population size...	0,38	0,11	0,09	0,52
		(9,77)	(2,88)	(2,75)	(15,66)
Municipal roads	Constant term..	0,16	0,09	0,06	0,15
		(4,40)	(3,71)	(3,17)	(5,36)
	Amount of snowfall..	0,02	0,05	0,06	0,05
		(3,02)	(9,90)	(17,11)	(8,46)
	Kilometers of municipal road...	21,27	23,00	20,10	18,34
		(19,73)	(27,53)	(35,68)	(23,63)
Water supply and sanitation	Constant term..	1,21	1,14	1,10	0,99
		(26,65)	(32,97)	(39,72)	(21,93)
	Capacity of advanced purification..	0,19	0,40	0,48	0,57
		(6,07)	(14,19)	(23,97)	(18,49)
	Inverse population size...	-0,20	-0,08	0,13	0,45
		(3,29)	(1,38)	(4,09)	(9,10)
Other infrastructure	Constant term..	-0,29	0,26	0,72	1,18
		(2,25)	(2,60)	(8,03)	(9,77)
	Inverse population size...	-	-	2,28	1,23
		-	-	(27,79)	(12,71)

T-values reported in parenthesis. All variables are measured in pro capita values. Coefficients are reported in thousands of 2008 NOK

Appendix D: Time heterogeneity

Figure D.1. Evolution of time coefficients

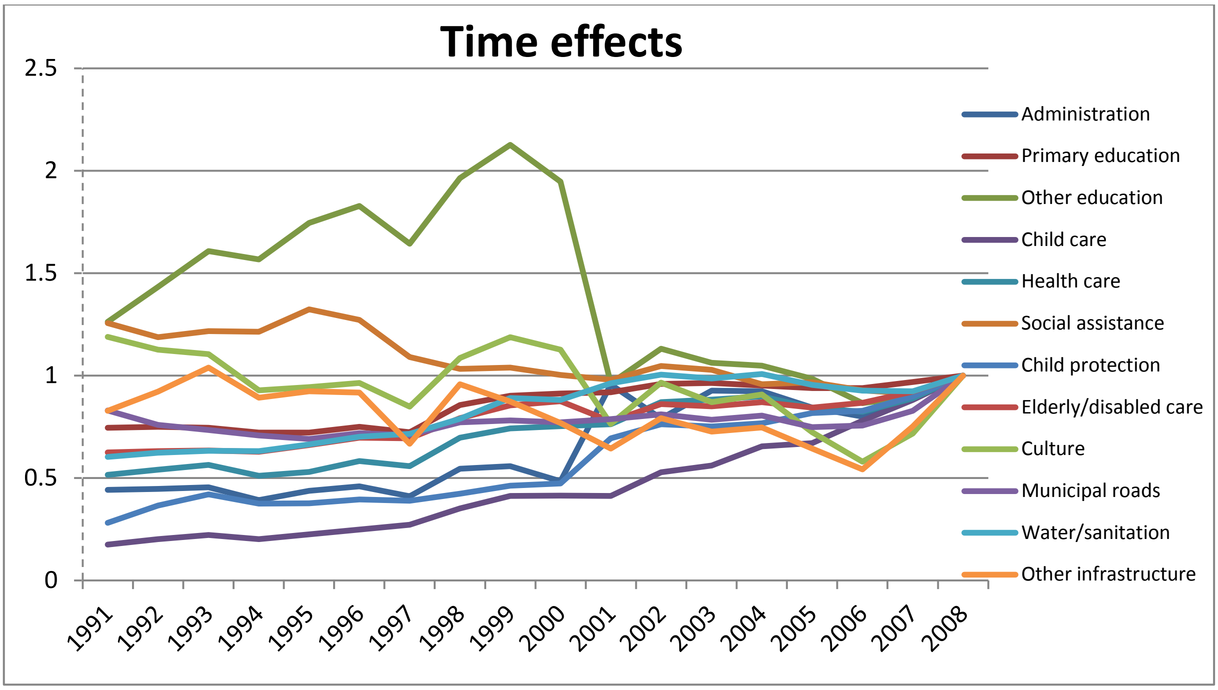
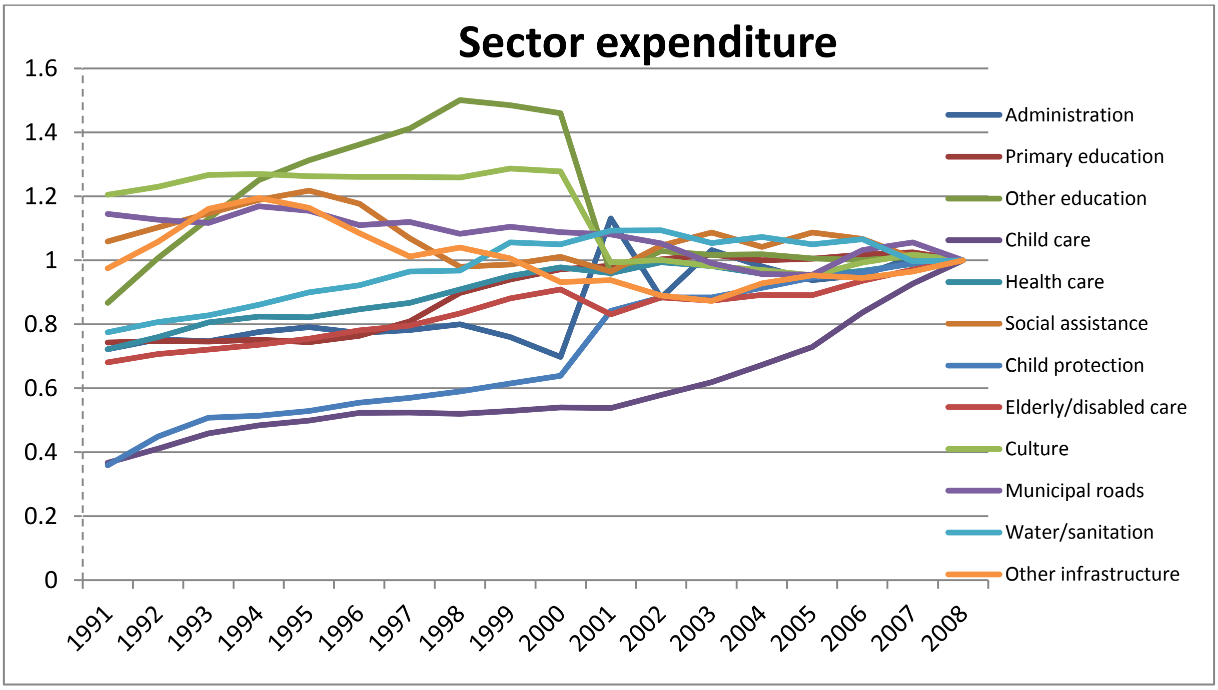


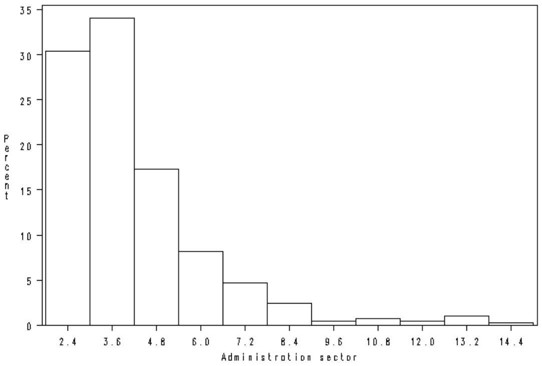
Figure D.2. Evolution of sector specific expenditure indices



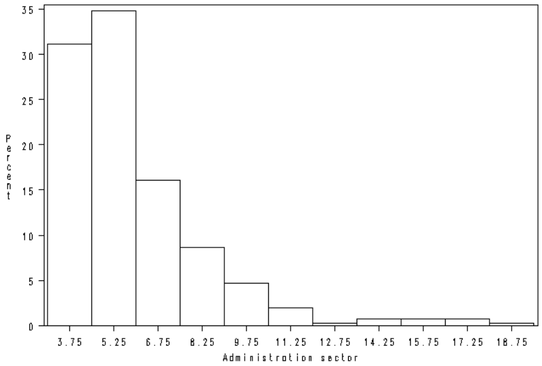
Appendix E: Minimum required expenditure

Distribution of minimum required expenditure per service sector for each model in 2008.

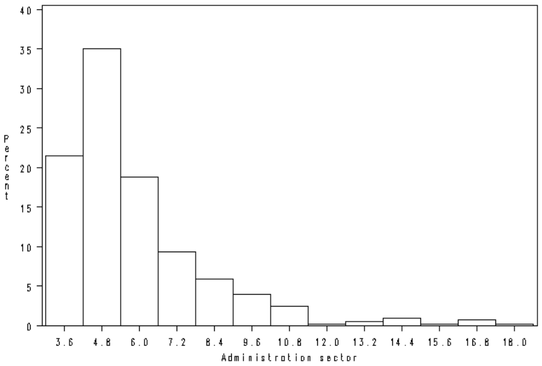
Distribution of minimum required expenditure in model 2 (2008)



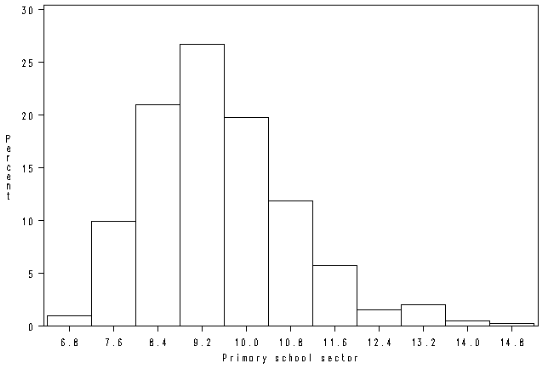
Distribution of minimum required expenditure in model 3 (2008)



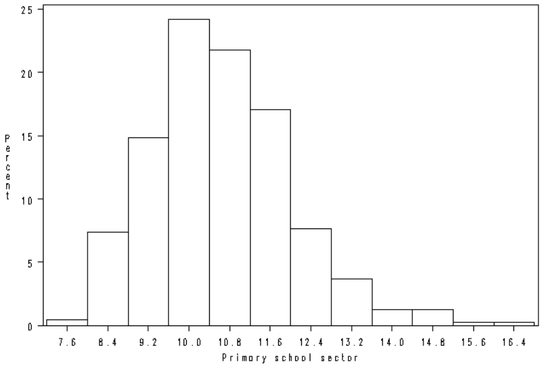
Distribution of minimum required expenditure in model 4 (2008)



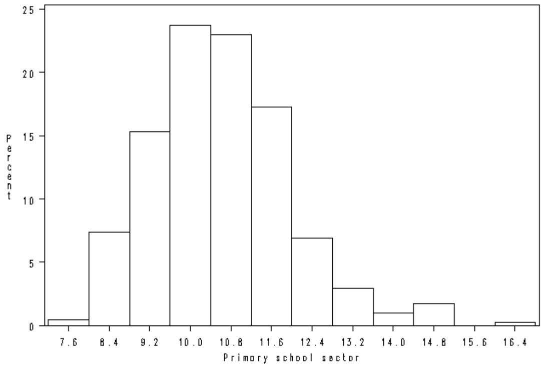
Distribution of minimum required expenditure in model 2 (2008)



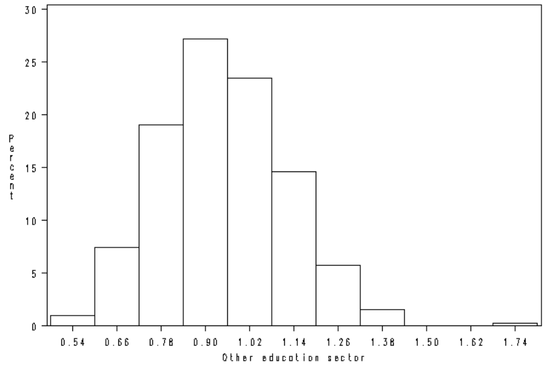
Distribution of minimum required expenditure in model 3 (2008)



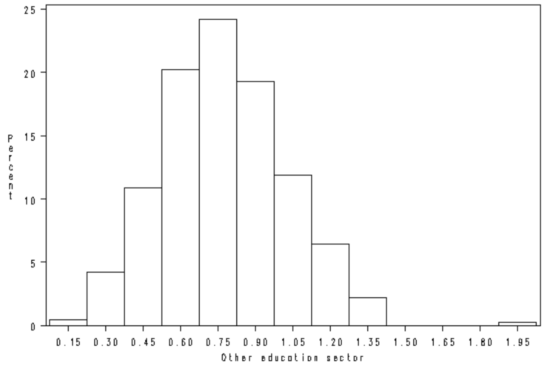
Distribution of minimum required expenditure in model 4 (2008)



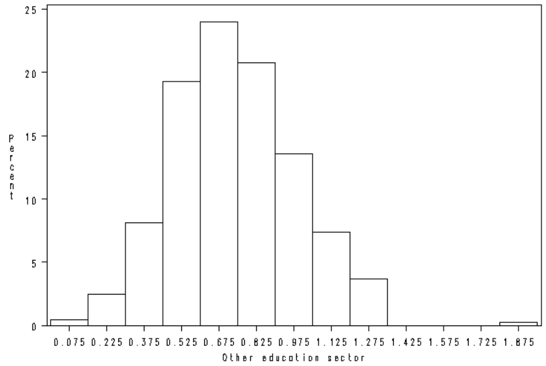
Distribution of minimum required expenditure in model 2 (2008)



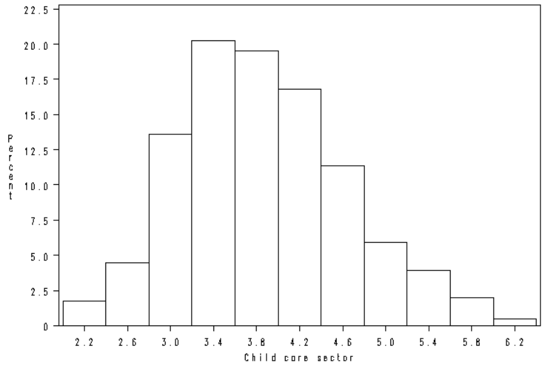
Distribution of minimum required expenditure in model 3 (2008)



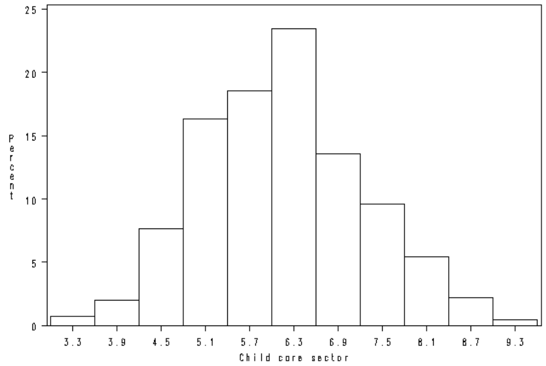
Distribution of minimum required expenditure in model 4 (2008)



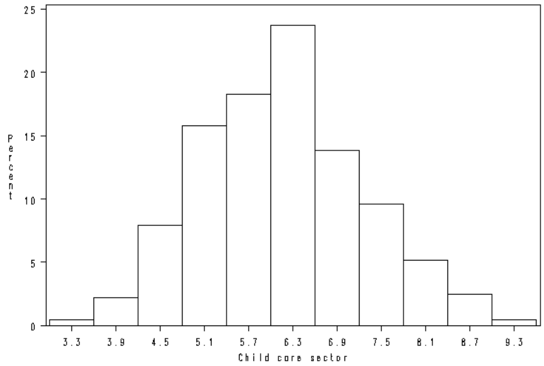
Distribution of minimum required expenditure in model 2 (2008)



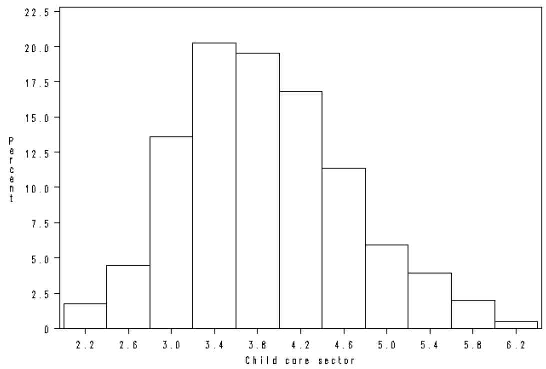
Distribution of minimum required expenditure in model 3 (2008)



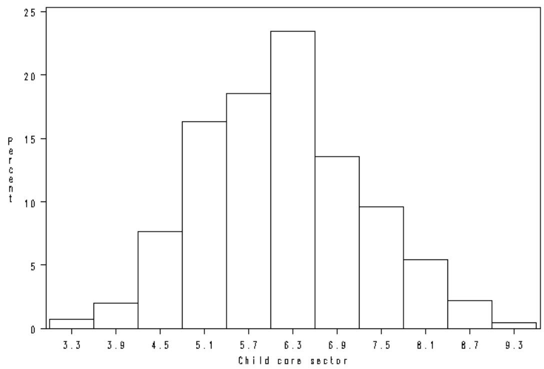
Distribution of minimum required expenditure in model 4 (2008)



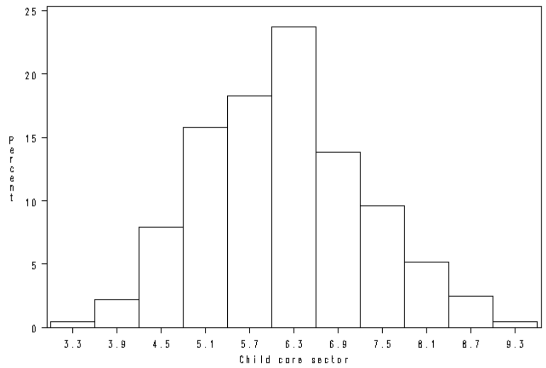
Distribution of minimum required expenditure in model 2 (2008)



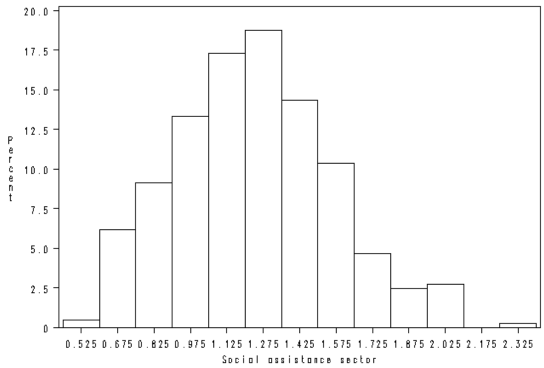
Distribution of minimum required expenditure in model 3 (2008)



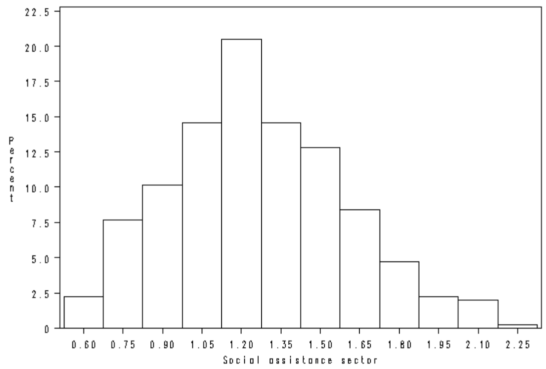
Distribution of minimum required expenditure in model 4 (2008)



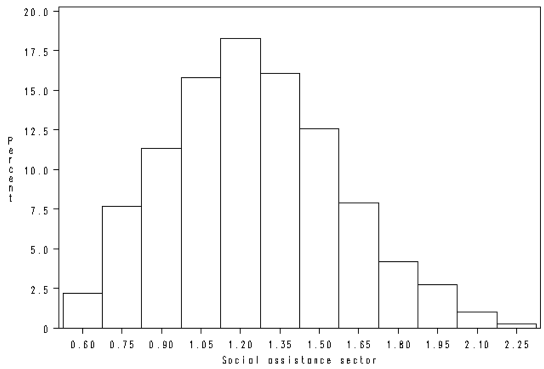
Distribution of minimum required expenditure in model 2 (2008)



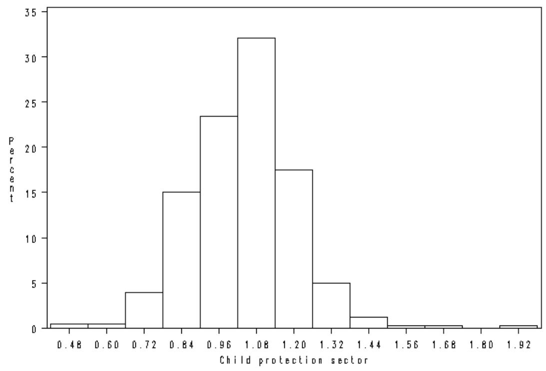
Distribution of minimum required expenditure in model 3 (2008)



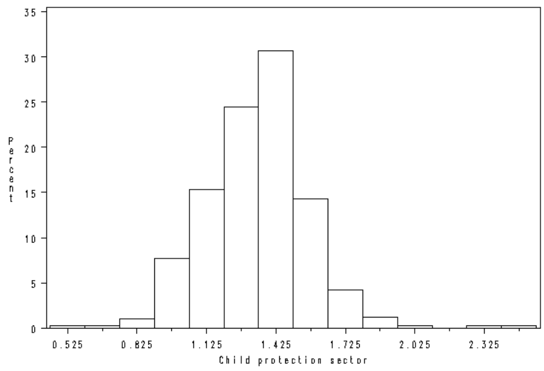
Distribution of minimum required expenditure in model 4 (2008)



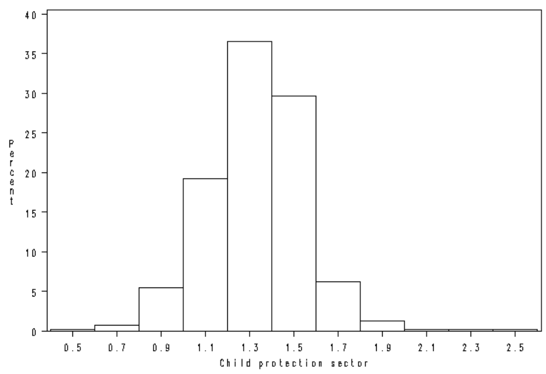
Distribution of minimum required expenditure in model 2 (2008)



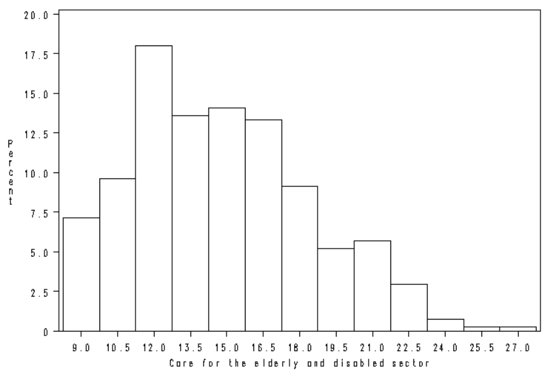
Distribution of minimum required expenditure in model 3 (2008)



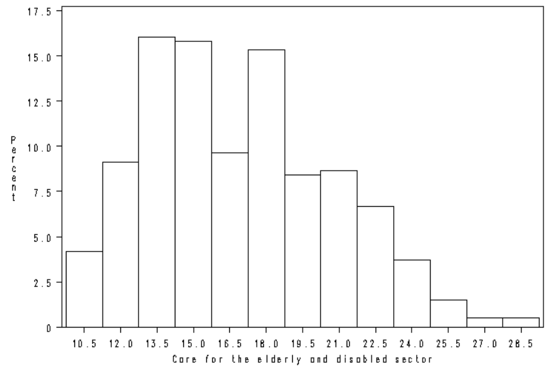
Distribution of minimum required expenditure in model 4 (2008)



Distribution of minimum required expenditure in model 2 (2008)



Distribution of minimum required expenditure in model 3 (2008)



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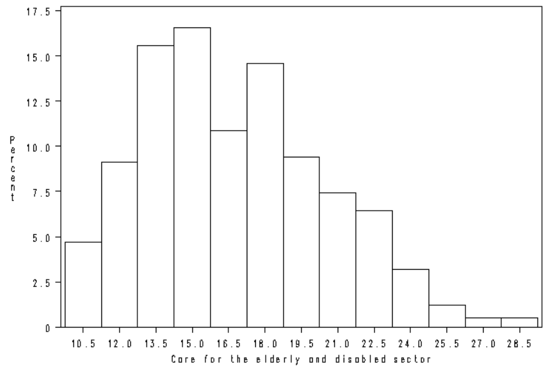

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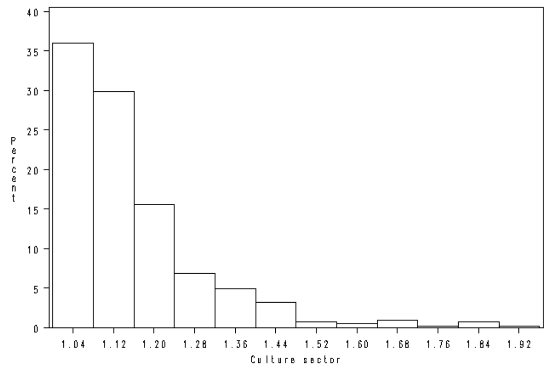

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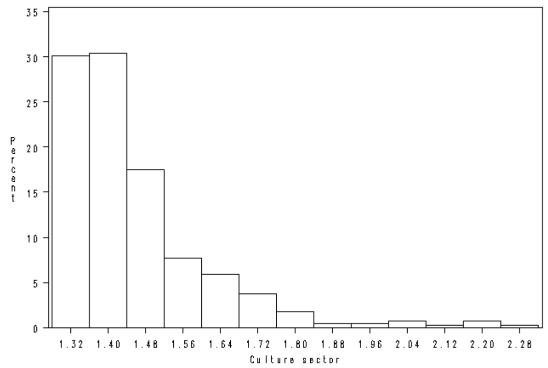

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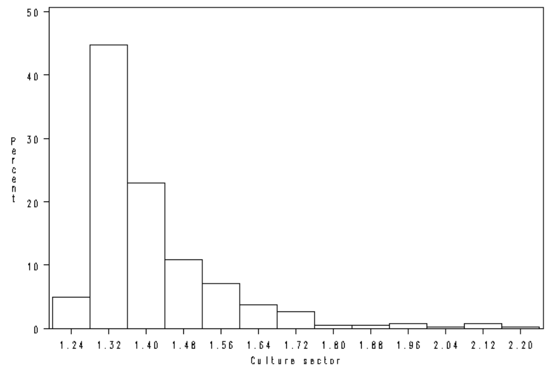

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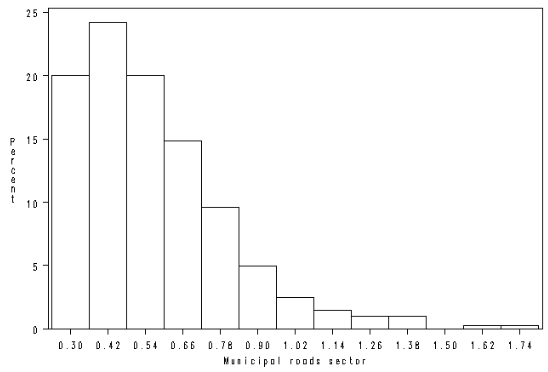

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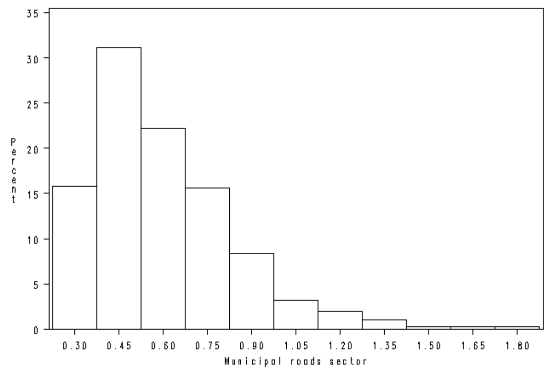
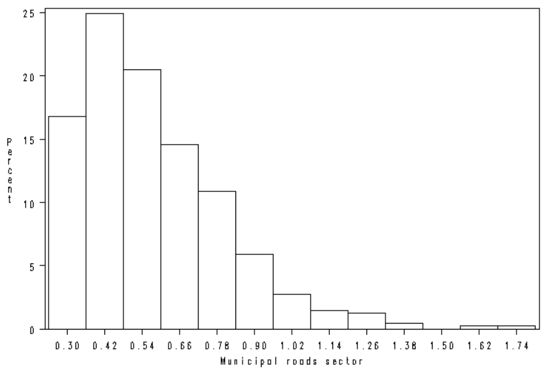


Distribution of minimum required expenditure in model 4 (2008)



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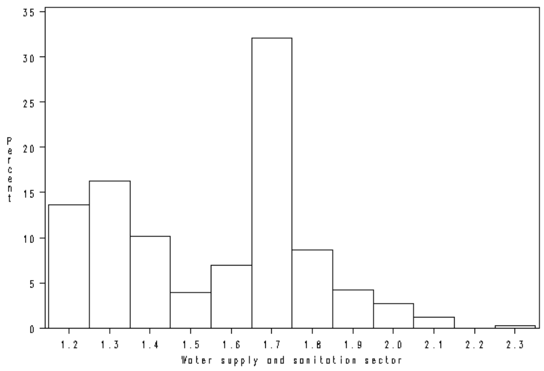

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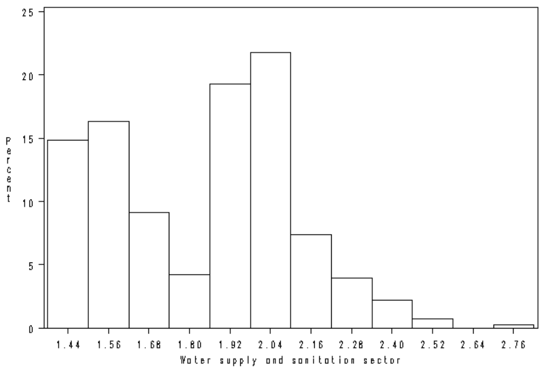

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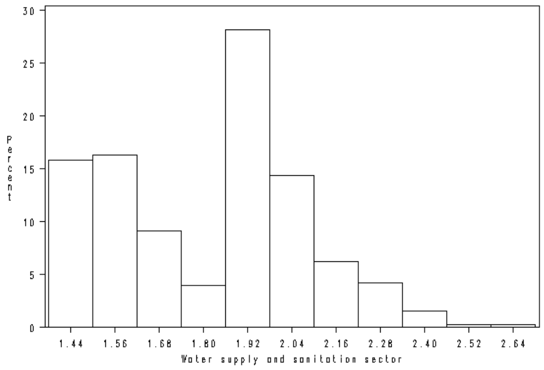

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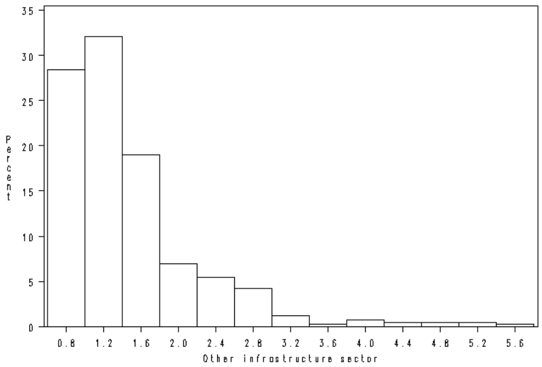

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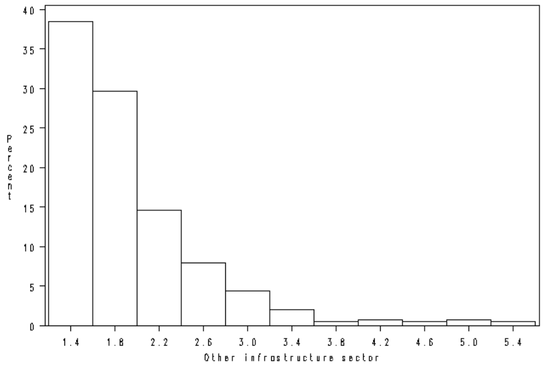

Distribution of minimum required expenditure in model 4 (2008)